AD NUMBER
AD869409
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 10 MAY 1970. Other requests shall be referred to Air Force Technical Applications Center, Washington, DC 20333.**
AUTHORITY
AFTAC ltr 25 Jan 1972

AFTAC Project No. VT/9707

alez, la - 2 23/3

LONG PERIOD ARRAY PROCESSING DEVELOPMENT

Quarterly Report No. 4

1 February 1970 to 30 April 1970

T. W. Harley, Program Manager
Area Code 292, 244-4894

TEXAS INSTRUMENTS INCORPORATED
Services Group
P.O. Box 5621
Dallas, Texas 75222

Contract No. F33657-69-C-1063
Amount of Contract: $391,000
Beginning 21 April 1969
Ending 21 February 1971

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D.C. 20333

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No. 624
ARPA Program Code No. 9F10

10 May 1970

Acknowledgment: This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract No. F33657-69-C-1063.

AFTAC Project No. VT/9707

LONG PERIOD ARRAY PROCESSING DEVELOPMENT

Quarterly Report No. 4

1 February 1970 to 30 April 1970

T. W. Harley, Program Manager
Area Code 292, 244-4894

TEXAS INSTRUMENTS INCORPORATED
Services Group
P.O. Box 5621
Dallas, Texas 75222

Contract No. F33657-69-C-1063
Amount of Contract: $391,000
Beginning 21 April 1969
Ending 21 February 1971

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D.C. 20333

Sponsored by

ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No. 624
ARPA Program Code No. 9F10

10 May 1970

Acknowledgment: This research was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, under Project VELA-UNIFORM, and accomplished under the technical direction of the Air Force Technical Applications Center under Contract No. F33657-69-C-1063.

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC.

Qualified users may request copies of this document from:

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

TABLE OF CONTENTS

SECTION	TITLE	PAGE
I	INTRODUCTION AND SUMMARY	I-1
II	ON-LINE PACKAGE	II-1
	A. INTRODUCTION	II-1
	B. PACKAGE CONFIGURATION	II-1
	1. VSC Develocorder Subtask	II-1
	2. Adaptive Processing Task	II-11
	C. PACKAGE OPERATION	II-17
	1. Operating Instructions	II-17
	2. Summary of Down Times	II-17
	3. Tape Utilization	II-19
	4. Transmission Statistics	II-19
	D. DOCUMENTATION	II-20
III	OFF-LINE PACKAGE	III-1
	A. INTRODUCTION	III-1
	B. PACKAGE CONFIGURATION	III-1
	1. Beam Analysis	III-1
	2. Noise Analysis	III-15
	3. Signal Analysis	III-35
	4. Tape Copy/Merge	III-50
	5. Event Plot	III-58
	C. PACKAGE CHECKOUT	III-61
IV	ALPA EVALUATION	IV-1
	A. INTRODUCTION	IV-1
	B. NOISE ANALYSIS	IV-1
	1. Spectral Studies	IV-1
	2. Two Component Rayleigh Wave Signal Extraction	IV-9
	C. SIGNAL ANALYSIS	IV-13
	D. FUTURE PLANS	IV-16

TABLE OF CONTENTS (CONT)

SECTION	TITLE	PAGE
V.	LONG PERIOD EXPERIMENT	V-1
	A. INTRODUCTION	V-1
	B. PACKAGE DESIGN	V-1
	1. LXMERG	V-4
	2. LXDALL	V-4
	3. LXSELE	V-4
	4. LXEDIT	V-5
	5. LXPLOT	V-8
	6. LXGEN	V-8
	7. LXTRAN	V-11
	8. LXMULT	V-11
	C. FUTURE PLANS	V-15
VI	REFERENCES	VI-1

LIST OF APPENDICIES

APPENDIX	TITLE	PAGE
A	ALPA ON-LINE OPERATING INSTRUCTIONS	A-1

LIST OF TABLES

TABLE	TITLE	PAGE
II-1	ABNORMAL TERMINATIONS OF ON-LINE PACKAGE	II-18
IV-1	PEAK POWER VALUES AT LOW FREQUENCY FOR SITE 3-3	IV-3
IV-2	PEAK COHERENCES BETWEEN COMPONENTS AT SITE 3-3	IV-7

LIST OF FIGURES

FIGURE	TITLE	PAGE
II-1	VSC DEVELOCORDER SUBTASK	II-3 to II-8
II-2	SUBROUTINE SIPHON	II-13
II-3	DATA FLOW THROUGH SUBROUTINE FILTER	II-16
III-1	GENERAL FLOW BEAMAN	III-3 to III-4
III-2	EVENT INITIALIZATION. BEAMAN EVENT	III-5 to III-6
III-3	EVENT BEAM DEFINITION. BEAMAN EVBMDF	III-7
III-4	REFERENCE SITE SPECTRA GENERATION. BEAMAN REFSIT	III-9
III-5	GENERATE BEAM TO BE PROCESSED. BEAMAN OBTAIN	III-10 to III-11
III-6	PROCESS BEAMS. BEAMAN BMPROS	III-13 to III-14
III-7	NOISAN GENERAL FLOW	III-16 to III-17
III-8	INEVPR	III-18 to III-20
III-9	ANALIN	III-21 to III-25
III-10	MULCOH	III-27 to III-28
III-11	FKSPEC	III-30 to III-31
III-12	DSPLAY	III-33 to III-31
III-13	SIGNAN GENERAL FLOW	III-36
III-14	PINIT	III-37
III-15	VINIT	III-38 to III-41
III-16	PREPAR	III-42 to III-44
III-17	RELATE	III-45 to III-47
III-18	TPCOPY GENERAL FLOW	III-51 to III-53

LIST OF FIGURES

FIGURE	TITLE	PAGE
III-19	INITAP	III-54 to III-55
III-20	EXCOPY	III-56 to III-57
III-21	EVPLOT GENERAL FLOW	III-59
III-22	PROCES	III-60
III-23	EVBTCH	III-62 to III-64
IV-1	PEAK POWER VALUES AT LOW FREQUENCY FOR SITE 3-3	IV-4
IV-2	MEAN DAILY TEMPERATURE AT ALPA	IV-5
IV-3	TWO-COMPONENT RAYLEIGH WAVE SIGNAL-EXTRACTION FILTER APPLIED TO "DESIGN" NOISE	IV-11
IV-4	TWO-COMPONENT RAYLEIGH WAVE SIGNAL-EXTRACTION FILTER APPLIED TO "OFF-DESIGN" NOISE	IV-12
IV-5	TWO-COMPONENT RAYLEIGH WAVE SIGNAL-EXTRACTION FILTER APPLIED TO 1/10/70 EVENT	IV-14
IV-6	"HANDLEY" RECORDED AT SITE 3-3, ALASKAN LONG PERIOD ARRAY	IV-15
V-1	LONG PERIOD EXPERIMENT DATA FLOW AND MAIN PROGRAM FUNCTIONS	V-2 to V-3
V-2	GENERAL FLOW LXEDIT	V-6 to V-7
V-3	LXGEN GENERAL FLOW	V-9 to V-10
V-4	GENERAL FLOW LXTRAN	V-12

SECTION I
INTRODUCTION AND SUMMARY

This fourth quarterly report describes progress made during the period 1 February 1970 to 30 April 1970 on the Long Period Array Processing Development program being conducted by Texas Instruments at the Seismic Array Analysis Center (SAAC). The purposes of the program are to develop on-line and off-line software to be used for evaluating the detection and discrimination capabilities of the Alaskan Long Period Array (ALPA) and to develop off-line software to be used for evaluating the detection and discrimination capabilities of stations of the Long Period Experiment.

The ALPA on-line package has been described previously in Quarterly Reports No. 1,[1] 2,[2] and 3.[3] The package was implemented on a continuous basis on 13 February 1970. Since that date, two additional on-line capabilities, described in Section II, have been added; the VELA Seismological Center (VSC) develocorder subtask, which outputs data for transmission over a 300 baud communication link to the VSC develocorder, and an adaptive processing algorithm (part of the block processor subtask), which provides an adaptive beam forming capability. The former was implemented on 11 March 1970; the latter will be implemented when data quality are adequate for on-line processing.

As of 30 April 1970, 77 days on-line operating experience has been obtained. Forty-two unscheduled program terminations have occurred; 17 due to machine or system problems, 10 due to operator or engineer errors, 9 because

the transmissions from ALPA stopped for an extended period and the program was deliberately taken down, 3 during implementation of the VSC develocorder subtask, and 3 due to other causes. Some improvement is to be expected by eliminating operator/engineer errors and because ALPA transmissions should become more continuous; however about 5 to 10 terminations per month should be expected. The unscheduled program terminations increase the rate at which library tapes are used, since a new tape must be mounted each time the program is initiated.

Transmission statistics summaries have indicated that the transmission link polycode error rate is fairly stable at about 1 in 10^6, but that problems developed with the ALPA timing word about 1 April 1970 in that many non-unity time increments occurred. This problem persisted through April.

The off-line package was described previously in Quarterly Reports No. 1, 2, and 3. Section III of this report describes the three off-line analysis programs; BEAMAN (processing and analysis of the output array beams), NOISAN (analysis of the array noise field), and SIGNAN (analysis of the signal characteristics across the array), and the two off-line utility routines; TPCOPY (which copies and merges off-line processing tapes) and EVPLOT (which plots time domain signal and noise data). The off-line package was completed 31 March 1970. Checkout included processing of two ALPA signals and signal and noise data from TFO which had been reformatted to the ALPA library tape format.

ALPA evaluation has been limited by data availability. The most serious problems have been the existence of at least one dead channel at several sites (which precludes coordinate rotation at those sites) and excessive spiking on some or all

of the channels, which apparently is caused by a problem in the radio data acquisition at ALPA. These problems have been especially serious in April.

In addition, high level non-seismic noise at periods greater than 20 seconds has been observed at all sites. This noise has been analyzed in detail and results are reported in Section IV. A method to extract the vertical channel Rayleigh wave signal from this noise has been developed and shown to be effective in suppressing the noise without distorting the signal.

During April an Engineering Change Proposal (ECP) to develop programs for processing and analysis of data from the Long Period Experiment stations was negotiated. Preliminary flow charting for this software package (designated LX) has been accomplished and is outlined in Section V.

SECTION II
ON-LINE PACKAGE

A. INTRODUCTION

In previous quarterly reports the basic design of the on-line package has been described and the main task, initialization task and six of the seven subtasks have been discussed. In this report the remaining subtask, named the VSC develocorder subtask, which prepares data for transmission to the VSC develocorder will be described in detail. In addition, the programming necessary to obtain an on-line adaptive processing capability (which will be performed in the block processor subtask) will be detailed.

The on-line package was implemented on a routine basis in 13 February 1970. Operating considerations and results are reviewed in this section.

B. PACKAGE CONFIGURATION

1. VSC Develocorder Subtask

The purpose of the VSC develocorder subtask is to control the output transmissions to the VSC develocorder. The data to be transmitted are created by the block processor and placed in the VSC buffer. The VSC develocorder subtask moves the data from the VSC buffer into a set of transmission buffers

from which the data actually are transmitted. One output command is responsible for all data transmitted (the data are stored in eight one-second buffers chained in a circular fashion). While data generated four seconds earlier are being transmitted the VSC develocorder subtask inserts current data into a position four buffers away in the circular chain. Figures II-1a through II-1f and the following discussion described in detail how the VSC develocorder subtask functions.

After priority of the VSC develocorder subtask is established by the control task and the subtask is activated it notifies the supervisor (using an ASYNC macro) that it is responsible for handling interrupts from the VSC 2701 data adapter. These interrupts occur immediately upon completion of transmission of one of the eight transmission buffers. After the ASYNC macro enables interrupt postings from the VSC 2701 data adapter, all eight transmission buffers are zeroed and the characters "DLE STX" are placed in the first two bytes of transmission buffer 0. The purpose of these two characters is to throw the 2701 into the transparent mode when it begins transmitting over the VELA link. The initialization procedure ends by issuing a start input/output (I/O) command to transmit data from the transmission buffers over the VELA link.

Once the start I/O command is given, the VSC develocorder waits for one of two events to happen; the SAAC develocorder subtask posts the event control block ECBVELA to indicate that the VSC develocorder 2701 has not triggered an interrupt for six seconds, or an interrupt is received from the VSC develocorder when one of the eight transmission buffers has been transmitted over the VELA link.

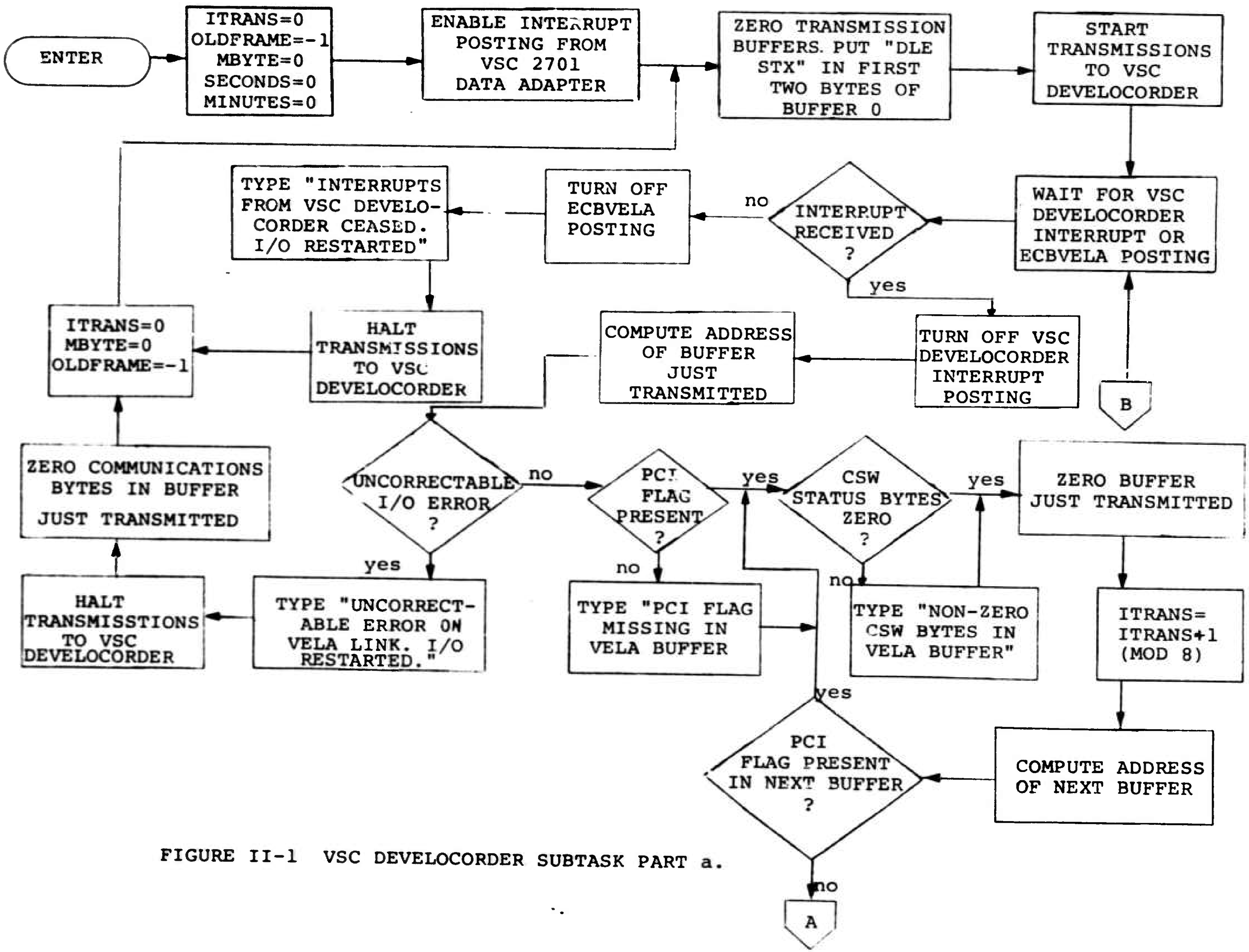


FIGURE II-1 VSC DEVELOCORDER SUBTASK PART a.

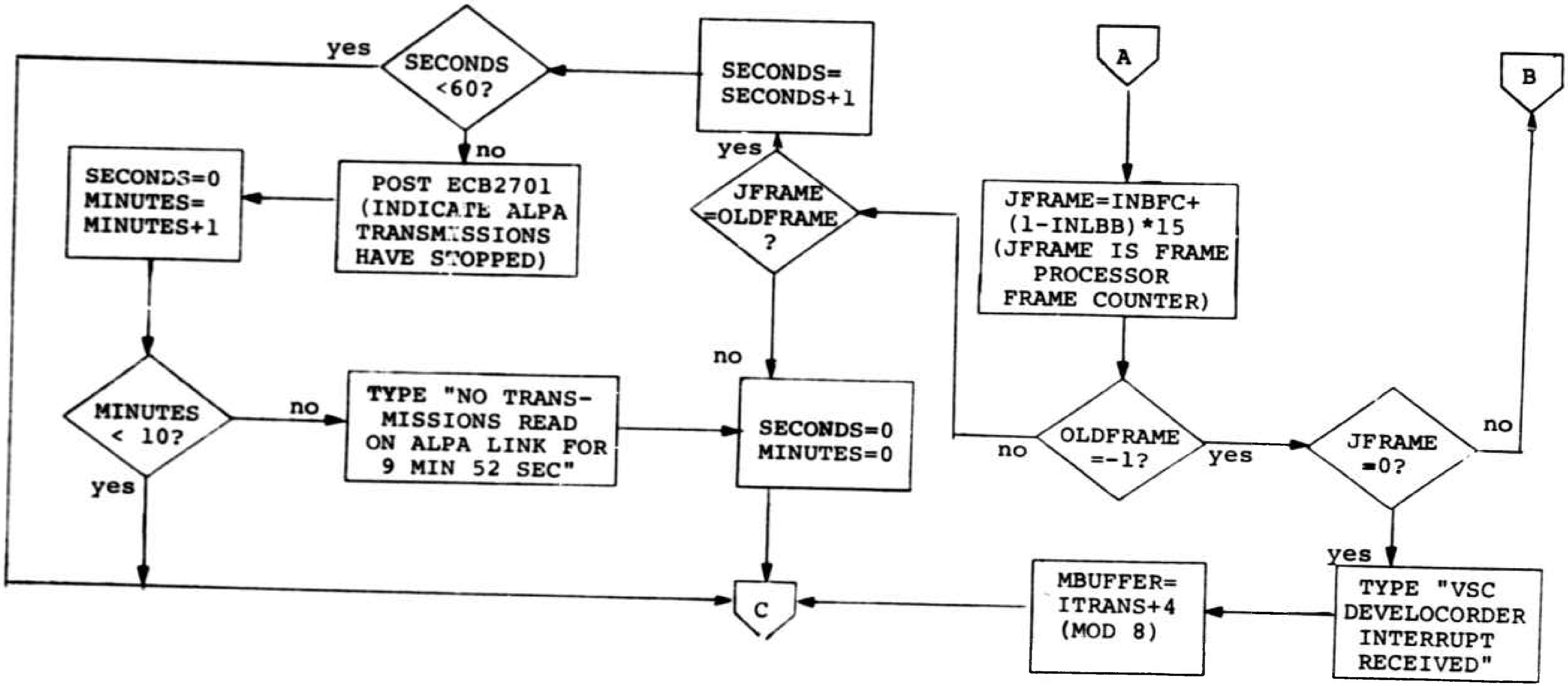


FIGURE II-1 VSC DEVELOCORDER
SUBTASK PART b.

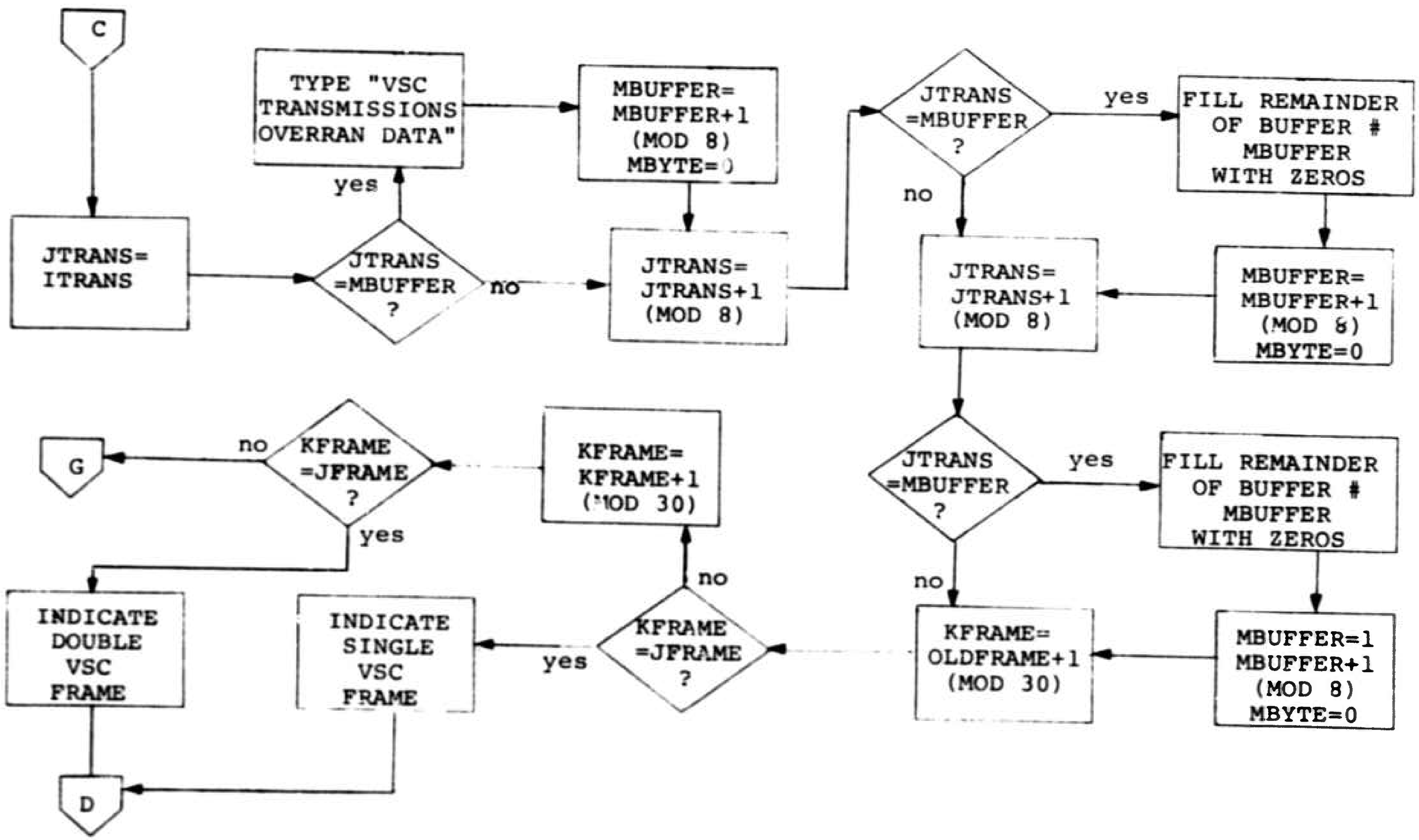


FIGURE II-1 VSC DEVELOCORDER
SUBTASK PART c.

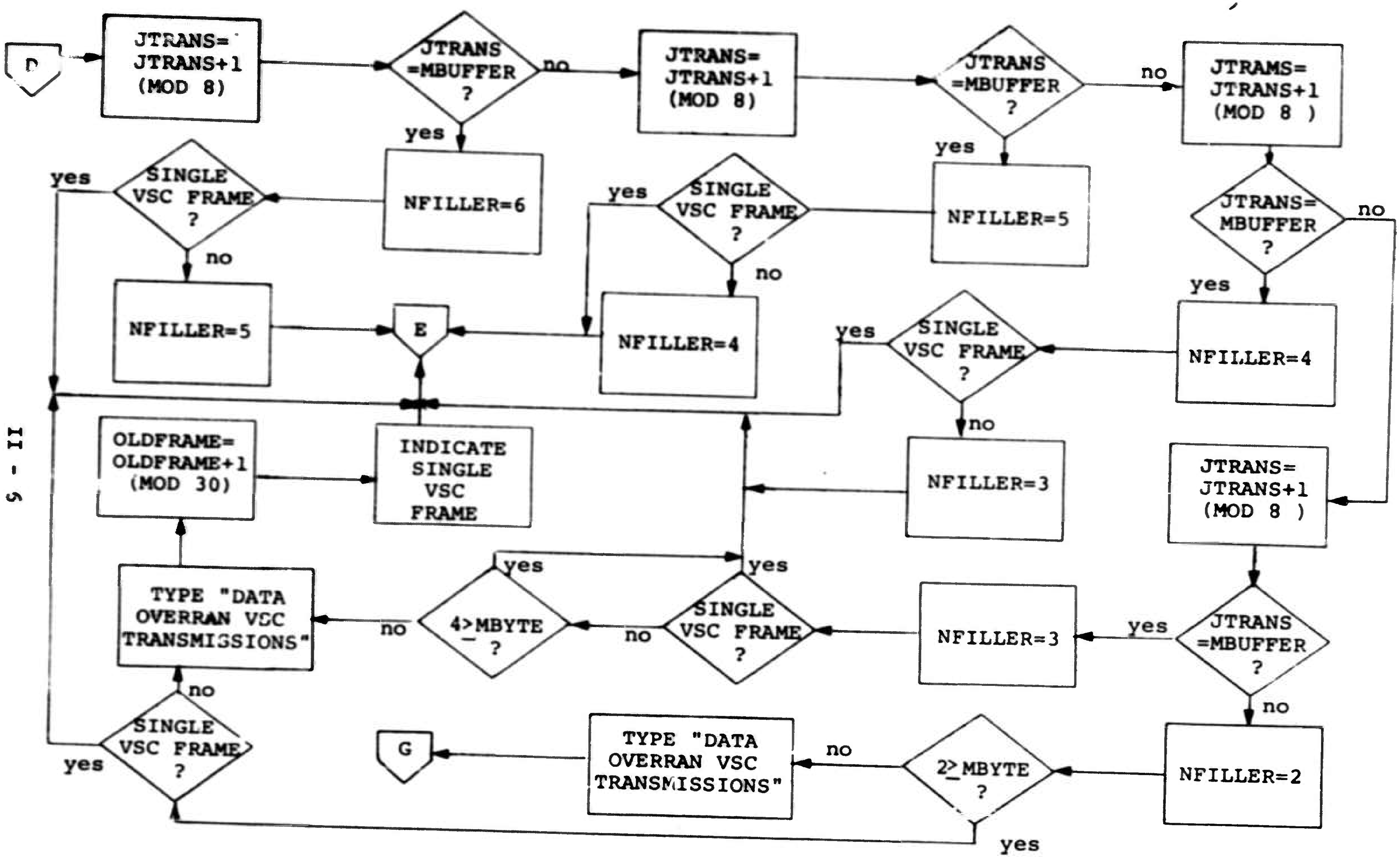


FIGURE II-1 VSC DEVELOCORDER
SUBTASK PART d.

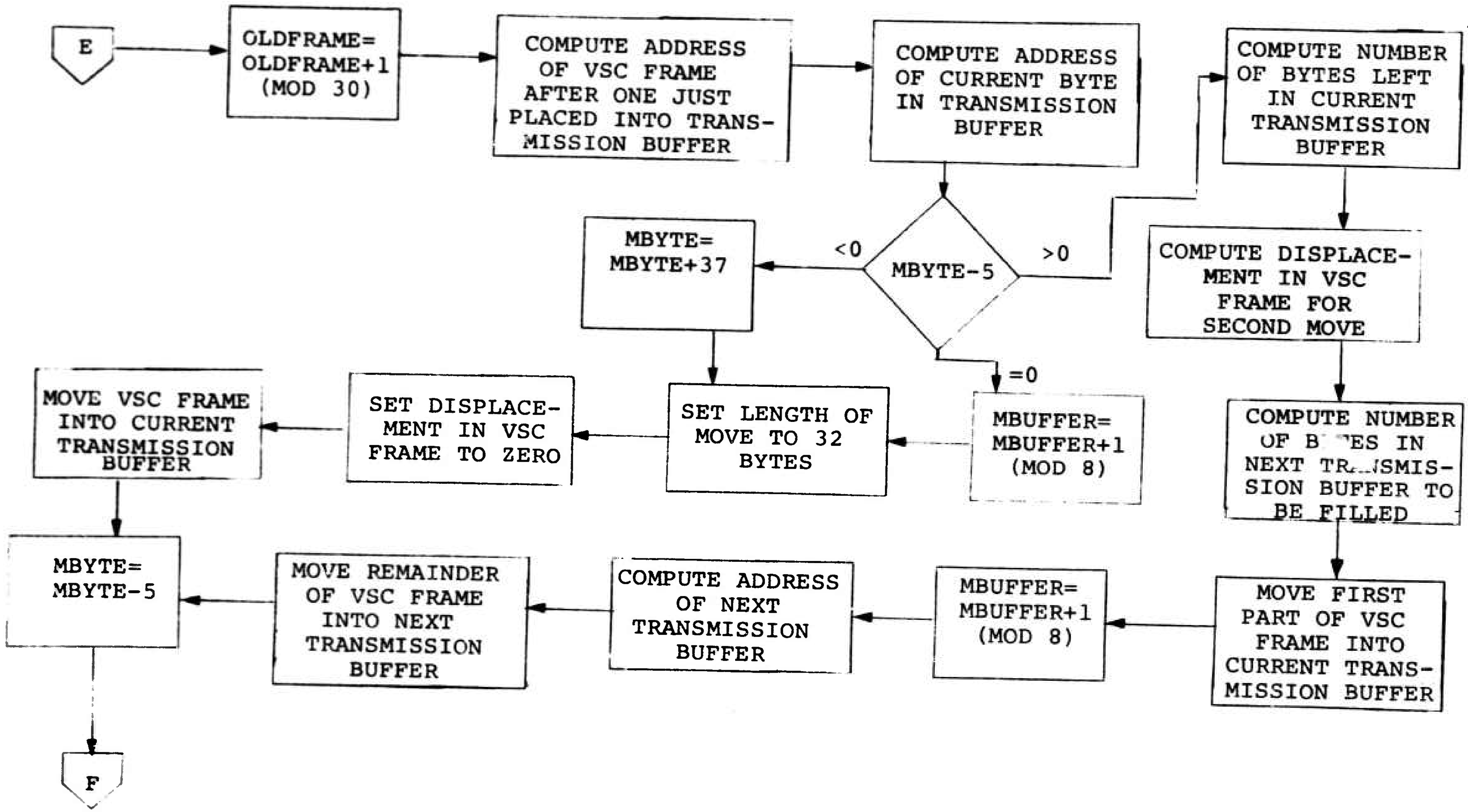


FIGURE II-1 VSC DEVELOCORDER
SUBTASK PART e.

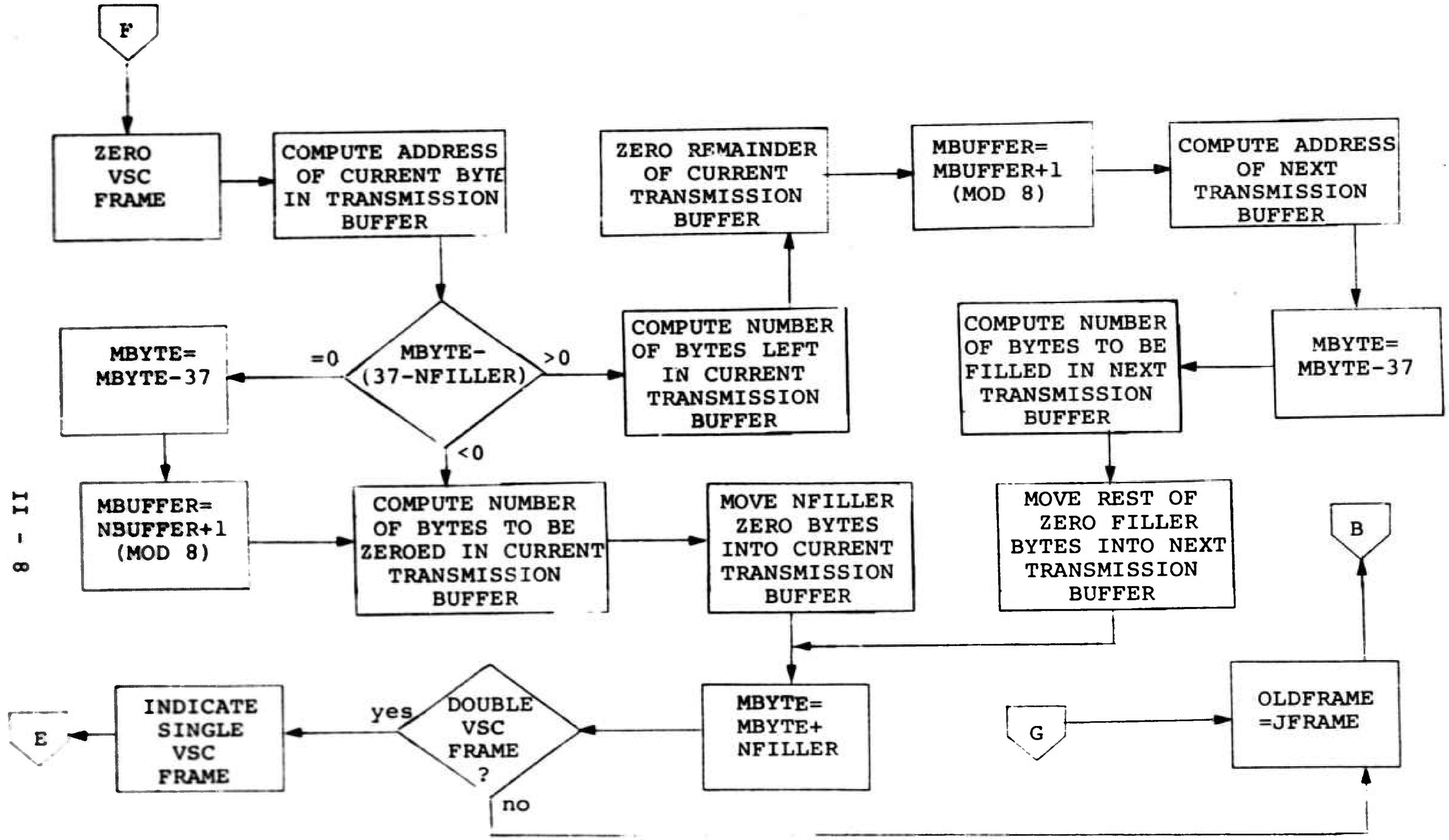


FIGURE II-1 VSC DEVELOCORDER
SUBTASK PART f.

The first event is abnormal. It means that the I/O chain for the VSC develocorder 2701 has been broken and that it is necessary to reinitiate transmissions over the VELA link. When this abnormal condition occurs, the ECBVELA posting is turned off, the message "INTERRUPTS FROM VSC DEVELOCORDER CEASED. I/O RESTARTED" is typed, a halt I/O command is given to the VSC develocorder, and the transmission counters are reset. The subtask then returns to the point in the initialization procedure where the transmission buffers are zeroed.

The second of these two events is what normally sets the subtask into motion: an interrupt occurs when one of the 37-byte transmission buffers has finished transmitting over the VELA link (every 74/75 seconds). When an interrupt is received, the VSC develocorder interrupt posting is turned off and the address of the buffer just transmitted is computed. Here the VSC develocorder error analysis and correction begins. If an uncorrectable error occurred, the message "UNCORRECTABLE ERROR ON VELA LINK. I/O RESTARTED." is typed, a halt I/O command is given to the VSC develocorder, the communications bytes for the buffer just transmitted are zeroed and the transmission counters are reset. The subtask then picks up at the point in the initialization procedure where the transmission buffers are zeroed. If an uncorrectable error did not occur, the program-controlled-interrupt (PCI) flag for the buffer just transmitted is verified to be present and the channel-status-word (CSW) status bytes are examined for errors. Any error conditions generate appropriate typed messages. Zeroes are placed in the buffer just transmitted to prevent repetition of transmitted data. The transmission buffer index is incremented to indicate the transmissions are occurring from the next

transmission buffer. The address of the next transmission buffer is computed and the PCI flag in this buffer is examined. If it is present, both buffers have been transmitted since the subtask last gained control and the process, beginning with the CSW-status-byte check, is repeated.

When a buffer is found that has not yet been transmitted, a counter is computed. This counter indicates the frame that the frame processor has just finished. The VSC develocorder subtask then attempts to sychronize its transmissions with the frame processor. If synchronication has not been achieved previously, the frame processor counter must be zero or the VSC develocorder subtask waits for the next interrupt. When it is found to be zero, the message "VSC DEVELOCORDER INTERRUPT RECEIVED" is typed, and the buffer counter for data to be placed in the transmission buffers is set to the transmission buffer index plus four (modulo 8). This means that data are placed in the buffer opposite the one being transmitted in the eight-buffer circularly-chained set. If synchronization has been achieved previously, the VSC develocorder subtask checks to see that incoming ALPA transmissions are being received satisfactorily. If a minute passes with no ALPA transsions, the event control block "ECB2701" is posted to cause the frame processor to restart transmissions from ALPA. If ten minutes pass without ALPA transmissions, a message to that effect is typed.

The next section of coding in the VSC develocorder subtask analyzes the position of transmission relative to the point where data are to be placed in the transmission buffer. If transmission is occuring in the same buffer where data are to be placed, a message "VSC TRANSMISSIONS OVERRAN DATA" is

typed and the point where data are to be placed is changed to the first byte of the next buffer. If a two-buffer safety margin is not present, the next two buffers are completed with zero filler bytes (which act as a syncronization code for the VSC develocorder electronics) and the point where data are to be placed is changed to the first byte of the buffer following the safety-margin buffers. In the event that the VSC transmissions are in no danger of overrunning the point where data are to be placed, those frames which have been made available since the last VSC develocorder interrupt was received are placed in the transmission buffers together with a number of zero filler bytes which tend to move the point where data are to be placed 180° out of phase with respect to the buffer which is being transmitted. If data to be placed in the transmission buffer should fall in the buffer being transmitted, no data are transferred and the message "DATA OVERRAN VSC TRANSMISSIONS" is typed.

After the placing of data in the transmission buffers is complete, the frame processor frame counter is saved for reference and the VSC develocorder subtask waits for another VSC develocorder interrupt or an ECBVELA posting.

2. Adaptive Processing Task

During the months of March and April, two subroutines were written to provide a time-domain maximum-likelihood adaptive filtering capability. For six channels and 31-point filters, these subroutines occupy approximately 6000 bytes of core and are expected to use 15% of the available central processor time. The first subroutine (SIPHON) is designed to select sites from the block processor and place the time-shifted vertical component for each site in an array located within the second subroutine (FILTER). FILTER utilizes these data points to form one adaptive beam, the corresponding conventional beam and a moving power

average for both beams. The beams may be optionally output on the SAAC develocorders. The beams and power averages may optionally be written over 4 of the 28 beams on the ALPA library tape.

The purpose of the subroutine SIPHON (Figure II-2) is to intercept data which has been defloated, shifted, and placed in the processing buffers by the block processor subtask prior to the quality check procedures employed there. From these data, certain sites are extracted, the vertical component formed for these sites, and an effective preliminary time shift applied to the vertical component for each site. The resultant time-shifted vertical-component output is placed into a data buffer 5 blocks (75 seconds) long. This data buffer is located within the subroutine FILTER, which actually implements the adaptive filtering algorithm.

The subroutine SIPHON has been programmed so that changes in the number of sites, number of one-second frames in a block, the number of channels to be used, etc., can easily be changed by using global set variables at the beginning of the subroutine. The variables, their meaning, and current values are:

- &NSITES Numbers of sites in processing buffers (19)
- &NFRPBLK Number of frames per block (15)
- &ACHAN Number of adaptively filtered channels (6)
- &ABLOCK Number of blocks in data buffer (5)
- &NFRMDBF Number of frames in data buffer (&ABLOCK*&NRFPBLK)

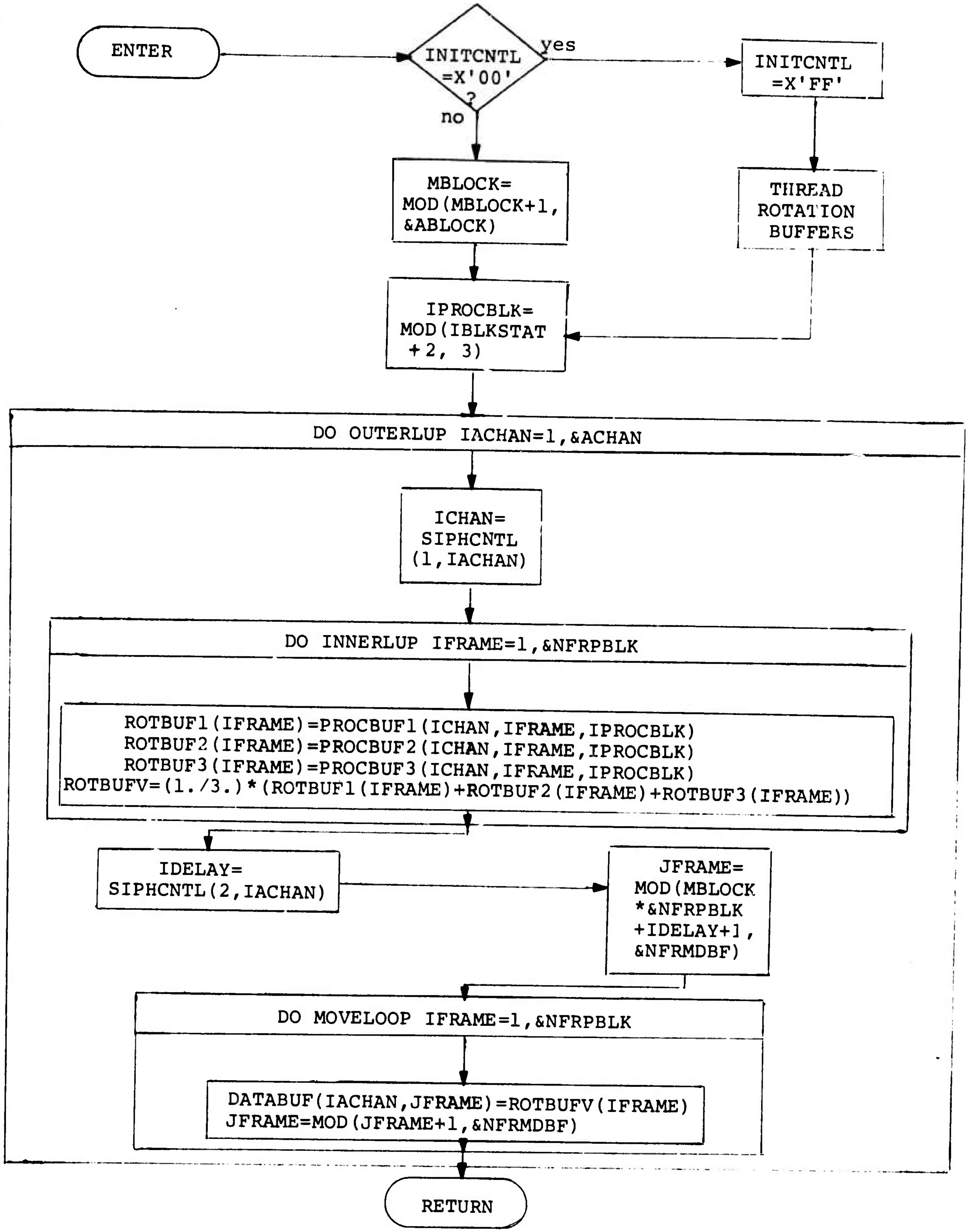


FIGURE II-2 SUBROUTINE SIPHON

All arrays used in SIPHON are halfword (16-bit) arrays. The following arrays are used:

- SIPHCNTL (2,&ACHAN)
  - The SIPHON control table, which contains the processing buffer site number and delay corresponding to each of the channels.

- PROCBUF1(&NSITES, &NFRPBLK,3)
  PROCBUF2(&NSITES, &NFRPBLK,3)
  PROCBUF3(&NSITES, &NFRPBLK,3)
  - These are the processing buffers for components 1, 2 and 3 of the &NSITES sites transmitted over the ALPA link. In each of these buffers there are 3 blocks of &NFRPBLK frames.

- ROTBUF1(&NFRPBLK)
  ROTBUF2(&NFRPBLK)
  ROTBUF3(&NFRPBLK)
  - These are the rotation buffers where components 1, 2 and 3 of the &NFRPBLK frames for a single site are placed prior to extracting the vertical component for that site (using the CFIL microcode).

- ROTBUFV(&NFRPBLK)
  - This is the buffer where the vertical component for &NFRPBLK frames of a single site is output by the CFIL microcode.

- DATABUF(&ACHAN, &NFRMDBF)
  - This is the data buffer in the subroutine FILTER where the time-shifted vertical components for each of the adaptively filtered channels are placed.

Certain variables shown in Figure II-2 require explanation. The variable INITCNTL controls the initialization procedure for SIPHON. This procedure consists of placing threaded addresses in the arrays ROTBUF1,ROTBUF2,ROTBUF3 and ROTBUFV for use by the CFIL microcode. Initially it is set to X'00'; this value indicates the above arrays need to be threaded. When they are threaded, it is set to X'FF' to indicate initialization is complete.

The variable MBLOCK indicates which of the &ABLOCK blocks in the array DATABUF is to receive the output from SIPHON.

The variable IBLKSTAT is controlled by the frame processor subtask and assumes the values 0, 1, or 2. It indicates which third of each processing buffer contains the data just defloated and shifted by the block processor.

The purpose of the subroutine FILTER is to compute one time-domain maximum-likelihood adaptive beam using data taken by SIPHON from the processing buffers in the block processor. The current channel processing table from the block processor is used to prevent the use of bad data from any of the sites selected for adaptive processing. FILTER also computes a conventional beam (steered to the same direction as the adaptive beam) and a moving power average for both the adaptive and conventional beams. Each of these four outputs is optionally written in any one of the 28 beam locations in the ALPA library tape buffer. Both the adaptive and the conventionally steered beams are optionally output on the develocorders at the SAAC installation.

Figure II-3 is an illustration of the data flow associated with the adaptive filtering subroutine FILTER.

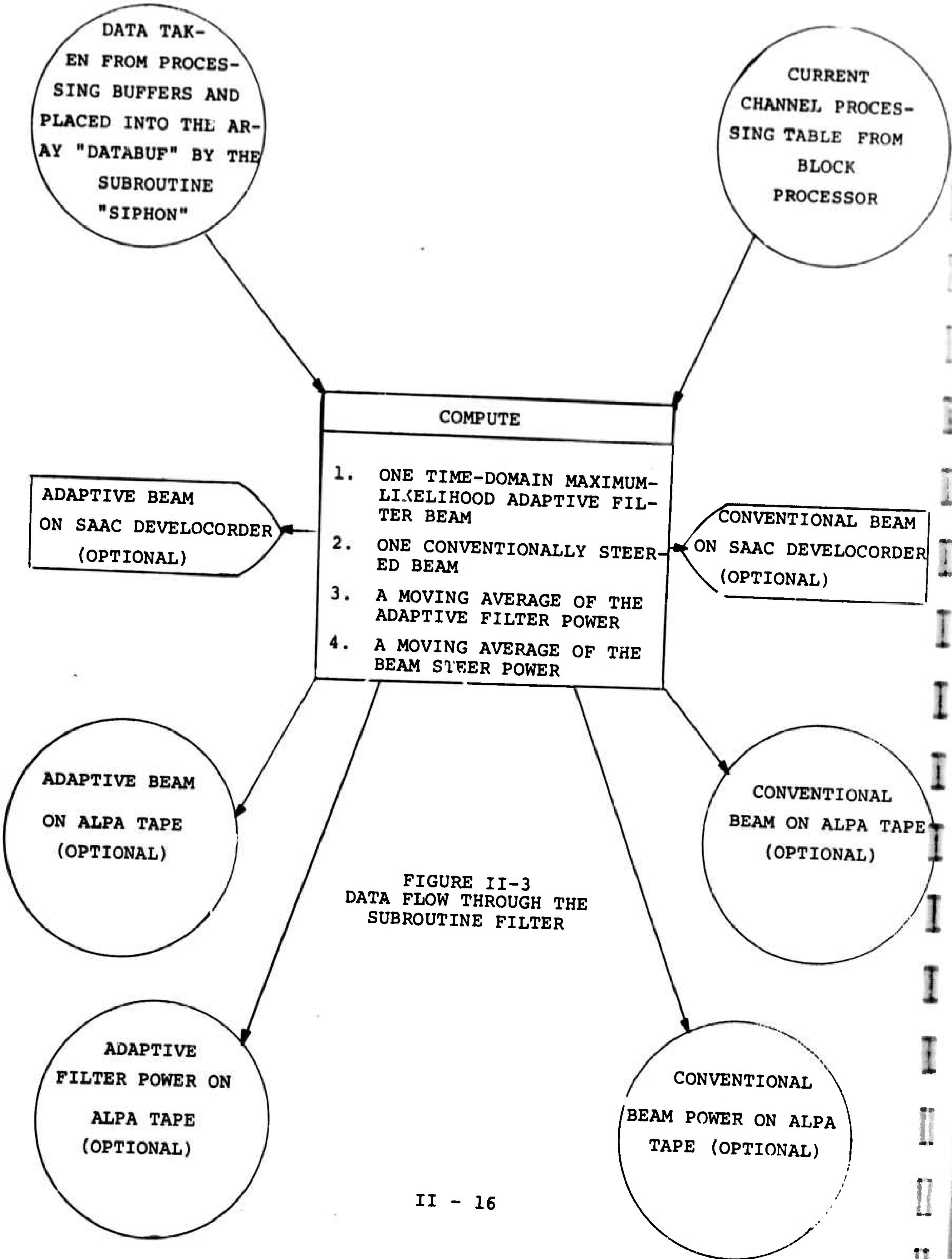


FIGURE II-3
DATA FLOW THROUGH THE SUBROUTINE FILTER

C. PACKAGE OPERATION

1. Operating Instructions

A set of operating instructions was prepared for running the ALPA on-line package. The latest version of these instructions is shown in Appendix A.

2. Summary of Down Times

As of 30 April 1970 the on-line package had been operating for 77 days. In this time there have been 42 abnormal terminations of the package; Table II-1 summarizes the causes for termination.

Hardware and system problems together have been the most frequent cause for termination. These are not easily controlled, and a certain number are to be expected. Hardware problems seem to occur in "bunches"; for example four machine checks occurred between 19 and 24 March 1970.

Operator and engineer errors can be attributed to unfamilarity with a new system. These can be controlled; there have been no operator errors and only one engineer error since 3 April 1970.

All three terminations due to programming modifications were associated with implementing the VSC develocorder subtask. The first termination was intentional, the last two were to correct for program errors.

TABLE II-1

ABNORMAL TERMINATIONS OF ON-LINE PACKAGE

CAUSE	NO OF OCCURRENCES
MACHINE CHECK OR MALFUNCTION (Hardware Problems)	14
SYSTEM PROBLEM	3
OPERATOR ERROR	3
ENGINEER ERROR	7
PROGRAM MODIFICATION	3
ALPA TRANSMISSION STOPPED	9
OTHER	3
TOTAL	42

When ALPA transmissions stop for an extended period the package is intentionally taken down, so that these terminations are abnormal only in the sense that they are unscheduled. The package could remain up (i.e., in a wait state) but it is more efficient from a computer utilization standpoint to take the package down so that the full capacity of the 40X can be used for other processing.

In the "other" category one termination was due to an anonymous bomb threat which closed SAAC, the other two occurred while experimenting with switching the plotter to and from the 40X.

3. Tape Utilization

Since ALPA on-line processing began on a regular basis, an average of slightly more than 24 hours of data has been written on the library tapes. This utilization rate is considerably less than the theoretically possible rate of 48 hours. The lower tape utilization is a result of the unscheduled down times described in the previous subsection (i.e., a new tape must be used each time the on-line package is initiated). As of 30 April, data are being written on tape number 63 of the 200 tapes allocated for on-line processing (100 tapes have been reserved for off-line processing). At the current rate the existing stock of library tapes should be used up by mid-September.

4. Transmission Statistics

Each hour the on-line package outputs several transmission statistics. The most important checks are the number of

polycode errors and the consistency of the ALPA timing word. To date the polycode error rate appears to be fairly stable at about 1 in 10^6 (3 errors per hour). Since 13 February 1970 two especially "noisy" days, when 30 to 40 errors per hour occurred, and 8 especially "noisy" hours, when more than 100 errors occurred, have been observed. In general, however, the transmission line performance has been reliable.

The ALPA timing word is checked in two ways: illegal time codes are flagged and non-unity time increments are counted. With the exception of two anomalous hours, only 9 illegal time codes have been observed since 13 February 1970. Up to about 1 April 1970 the number of non-unity time increments was quite small. Since that time, however, the ALPA timing word has been erratic as indicated by a substantial increase in the number on non-unity time increments. In addition, there have been periods when either the Julian date or the GMT Hour (or both) were incorrect. The problem apparently is in the time code interface at the MMC and it currently is under review.

D. DOCUMENTATION

Work has begun on the documentation for the on-line package. On-line documentation should be completed late in the fifth quarter.

SECTION III
OFF-LINE PACKAGE

A. INTRODUCTION

In previous quarterly reports the basic design of the off-line software has been outlined and the editing and signal enhancement programs have been discussed in detail. In this report the analysis and utility programs will be described. Analysis programs are: beam analysis (BEAMAN), which analyzes beams output from the signal enhancement section of the off-line package; noise analysis (NOISAN) which provides the capability to study the ALPA noise field, and signal anaylsis (SIGNAN), which provides the capability to study ALPA signal characteristics across the array. Utility programs are tape merge/copy (TPCOPY) which allows general manipulation of off-line data tapes, and event plot (EVPLOT) which provides the capability to Calcomp plot time-domain data.

Coding and checkout of the off-line package was completed in the fourth quarter. Final software checkout procedures are described in this report.

B. PACKAGE CONFIGURATION

1. Beam Analysis

The processing of time-domain beams is handled by the program BEAMAN. The primary functions of the program are output

beam processing and spectral and discrimination analysis. The general flow for BEAMAN is shown in Figure III-1.

In the program flow, the first major task, Figure III-2, is the event processing initialization. This task reads the event processing parameter cards, searches the input beam tape for the desired event, lists the header from the desired event, generates the event processing parameters and the input and output processing arrays, and initializes the Calcomp plot variables. The processing parameters generated are:

- Time and number of data points for each mode

- Number of transform points and frequencies, beginning transform time, and FORTRAN index of first data point for each mode

- Determination of processing acceptability of input master waveforms (comparison of input number of master waveform frequencies with the number of frequencies in the corresponding mode of processing)

- Generation of chirp filters and band pass filters.

From the processing parameters and the input data cards, input and output processing parameter arrays are generated (Figure III-3). The following parameters are generated for each output process.

- Type of beams to be processed:

- Power spectra print control flag - output spectra with reference trace and/or improvement of output spectra over

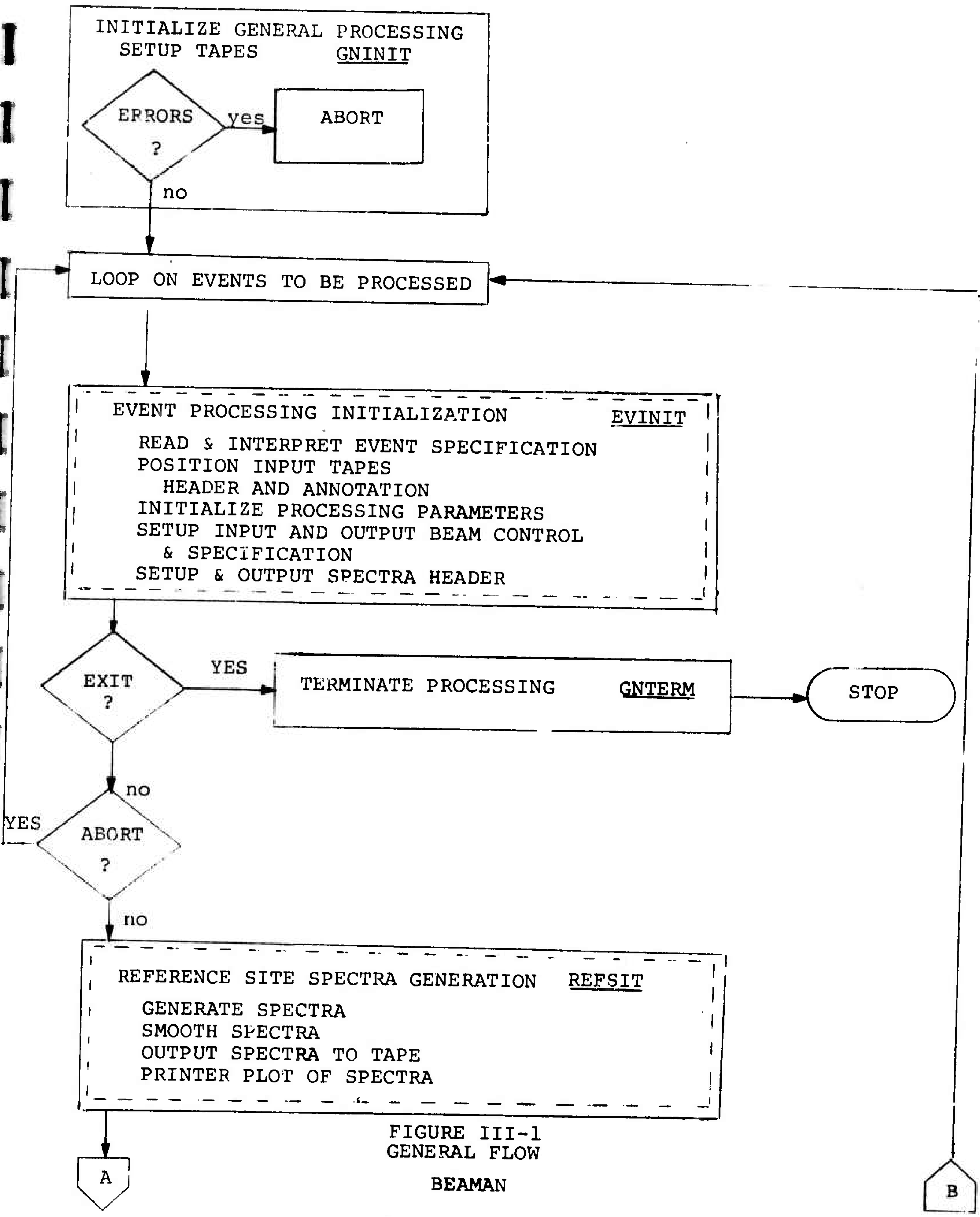


FIGURE III-1
GENERAL FLOW

BEAMAN

PAGE 1 OF 2 PAGES

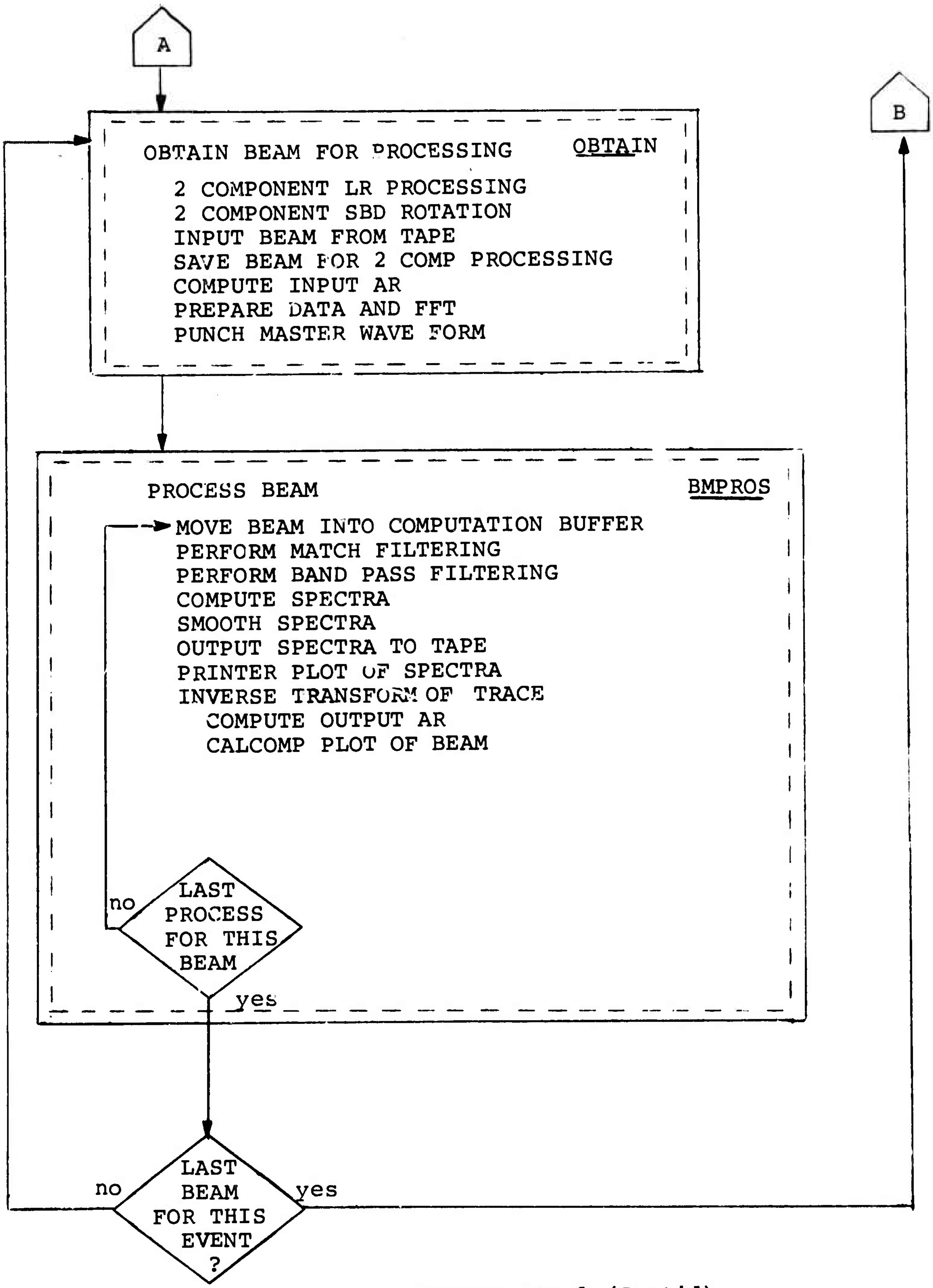


FIGURE III-1 (Cont'd)

GENERAL FLOW
BEAMAN

PAGE 2 OF 2 PAGES

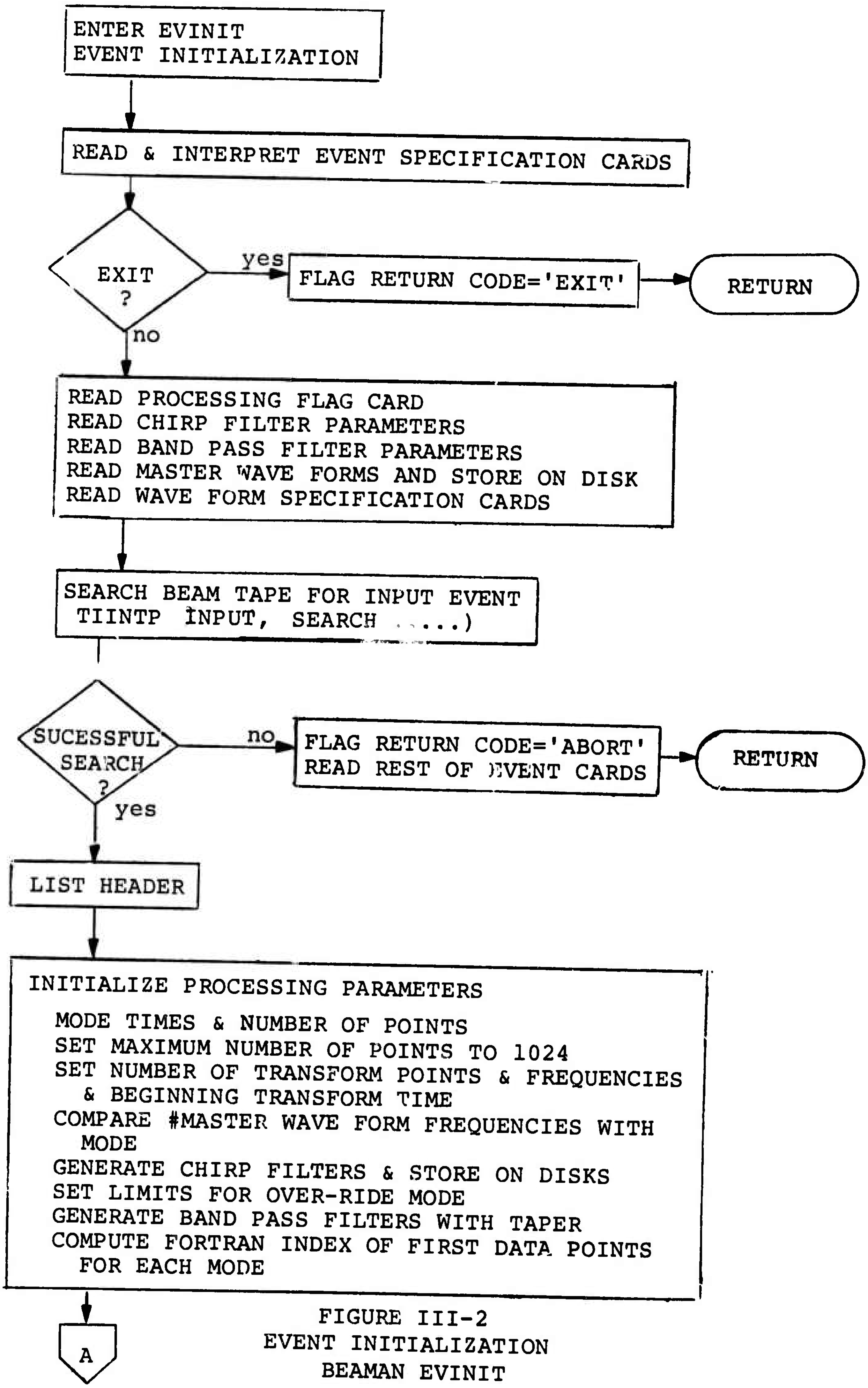


FIGURE III-2
EVENT INITIALIZATION
BEAMAN EVINIT

PAGE 1 OF 2 PAGES

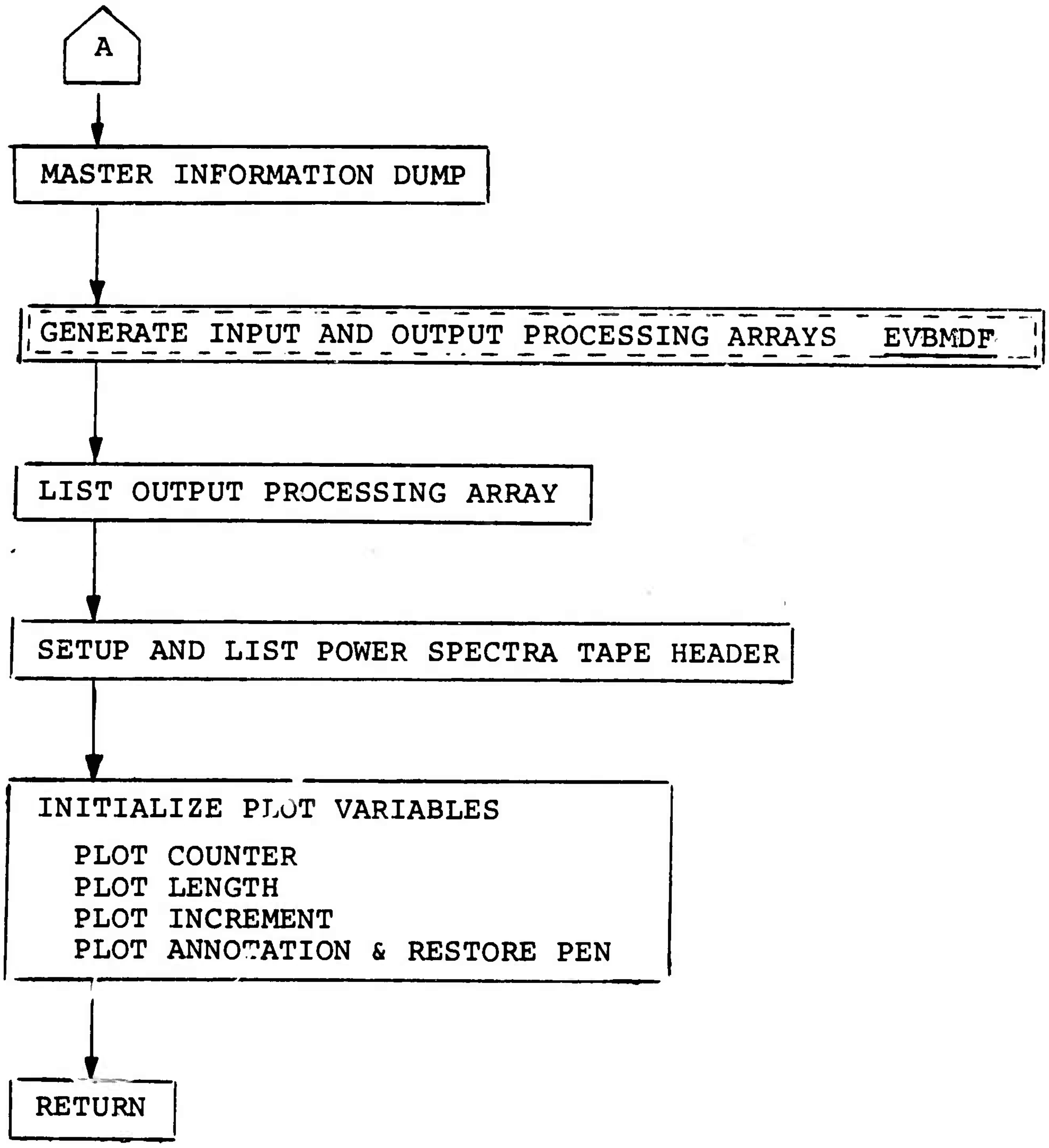


FIGURE III-2 (Cont'd)

EVENT INITIALIZATION
BEAMAN EVINIT

PAGE 2 OF 2 PAGES

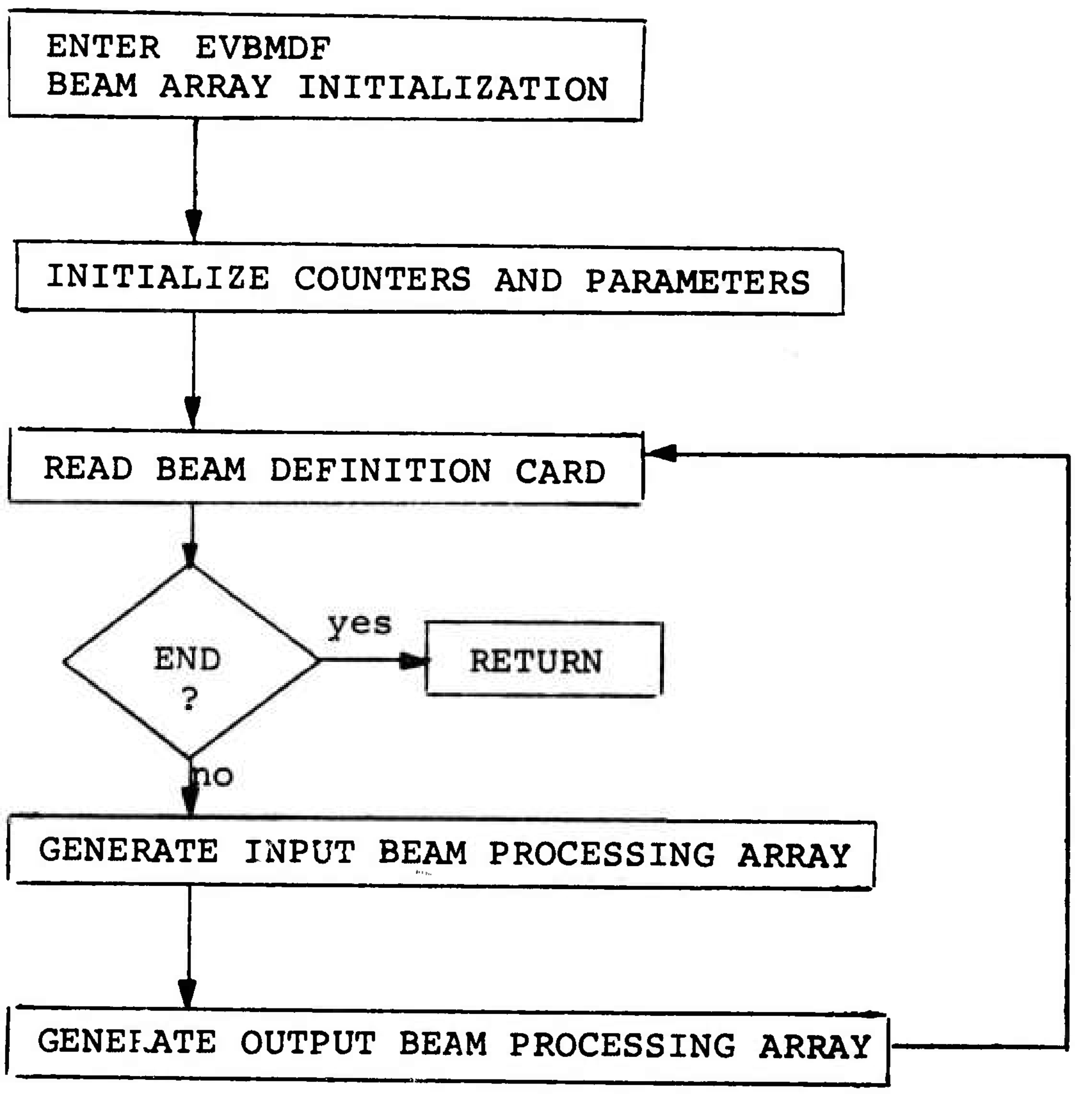


FIGURE III-3

EVENT BEAM DEFINITION
BEAMAN EVBMDF

reference trace

- Chirp filter number to be applied (zero equals none)

- Master waveform application flag

- Bandpass filter number to be applied (zero equals none)

- Control flags for computing input data trace and output processed trace AR values

- Flag for using over-ride limits instead of limits for mode from beam tape.

The next major program section is the calculation of the raw reference site surface wave spectra (Figure III-4). These spectra are computed first for each event so that the appropriate one may be included in later plots. One spectra is computed for each component. The desired portion of the input trace is moved to a transform buffer, scaled, and Fourier transformed. The spectra are generated from the transforms and smoothed to a maximum of 64 frequencies. Resulting spectra are written on an output spectra tape and plotted on the printer.

To speed up computation, the remaining flow of the program obtains the transform of each beam once and then performs all desired processing on that beam transform. Figure III-5 shows the flow for obtaining a transform of the desired mode (subroutine OBTAIN). The three data types used as input to the beam transform subroutine are:

- "Raw" beams output from TDFILT

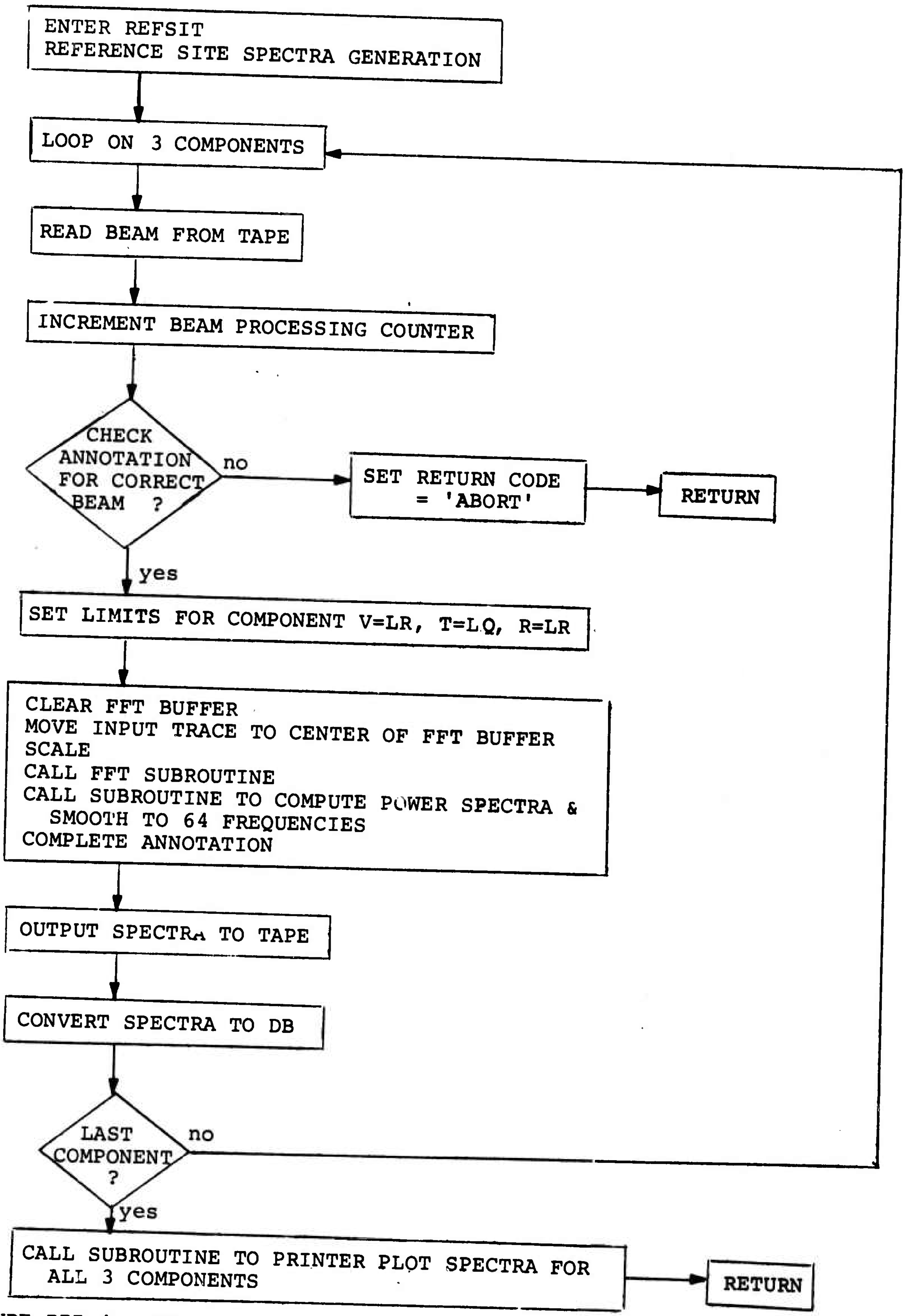


FIGURE III-4 REFERENCE SITE SPECTRA GENERATION
BEAMAN REFSIT

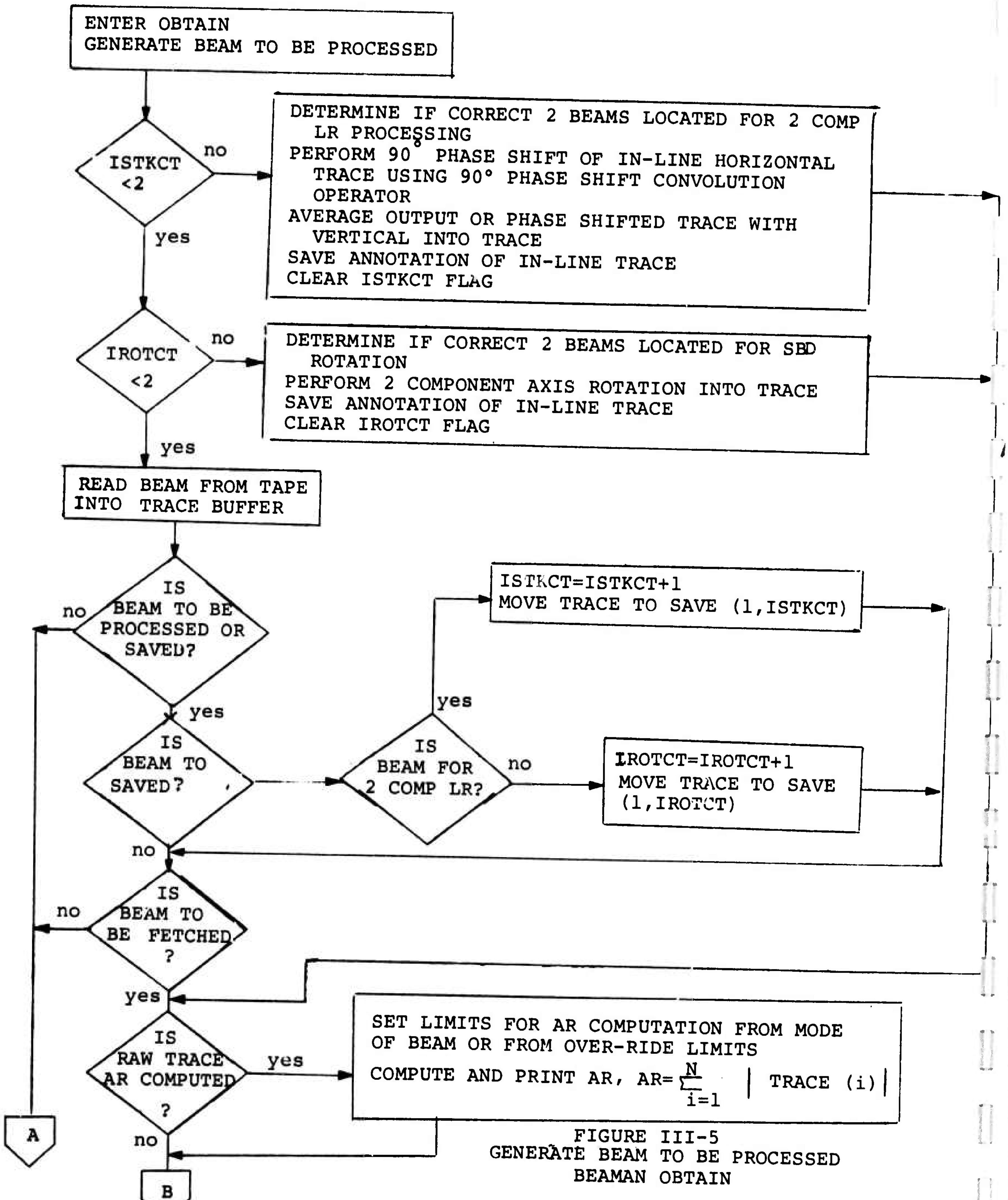


FIGURE III-5
GENERATE BEAM TO BE PROCESSED
BEAMAN OBTAIN

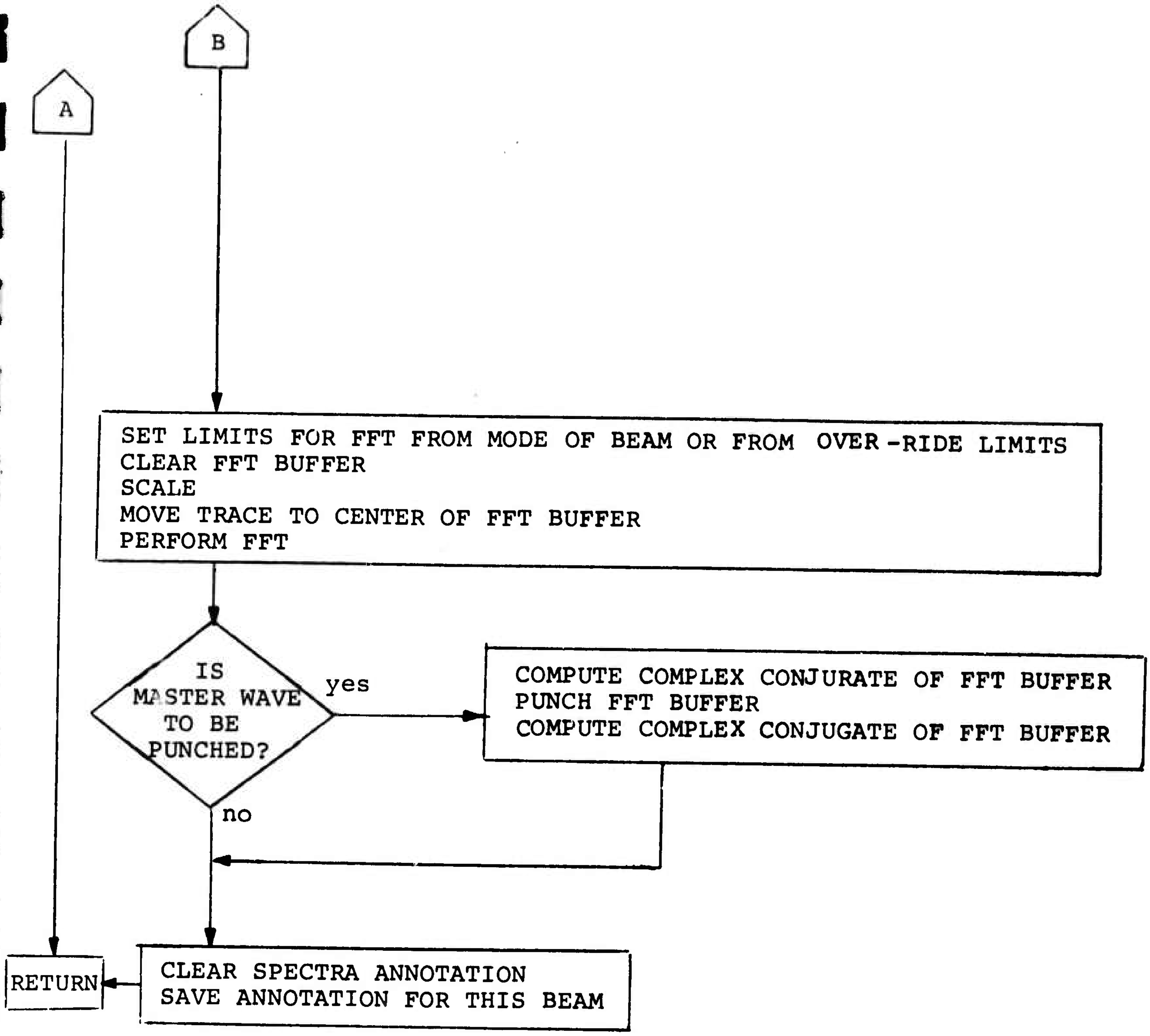


FIGURE III-5 (Cont'd)
GENERATE BEAM TO BE PROCESSED
BEAMAN OBTAIN

PAGE 2 OF 2 PAGES

- An LR beam obtained by phase-shifting the radial LR beam by 90° and stacking it with the vertical LR beam

- New horizontal beam obtained by rotating the "raw" horizontal beams to a secondary beam direction

OBTAIN minimizes tape reading time by saving those input beams to be used for further two-component processing. Therefore, OBTAIN first checks to see if both necessary beams have previously been saved. If so, then the new beam is generated as described above. If not, then the program reads a new trace from the input beam tape and processing is executed.

When the beam to be processed has been generated, the program computes AR on the desired mode of the input trace, where AR is the sum of the absolute values of all data points in the mode. The data are Fourier transformed and stored in a processing buffer; the transform of any beam may be output on punched cards and used as a master waveform in future processing. Also, annotation is stored with the transforms for later processing.

All desired transform processing is performed by subroutine BMPROS, Figure III-6. The first action in BMPROS is to move the transform into a processing buffer (where transforms are saved until processing is completed). Each transform is matched filtered (using either master waveforms or chirp filters) and/or band pass filtered, and the annotation is completed. The power spectra after processing is computed and smoothed to 64 frequencies. The spectra may be saved on tape and/or plotted on the printer with the reference spectra.

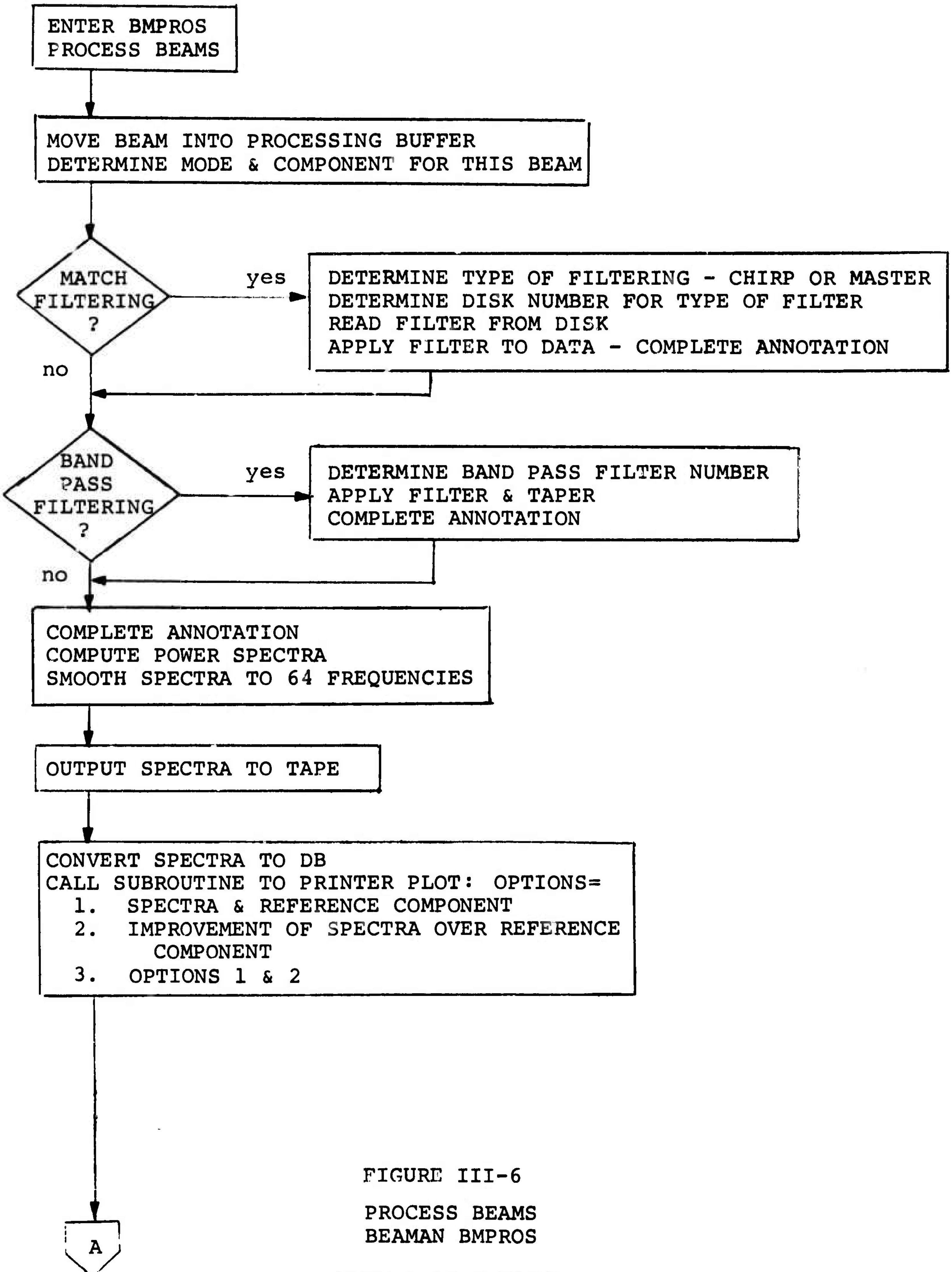


FIGURE III-6

PROCESS BEAMS
BEAMAN BMPROS

PAGE 1 OF 2 PAGES

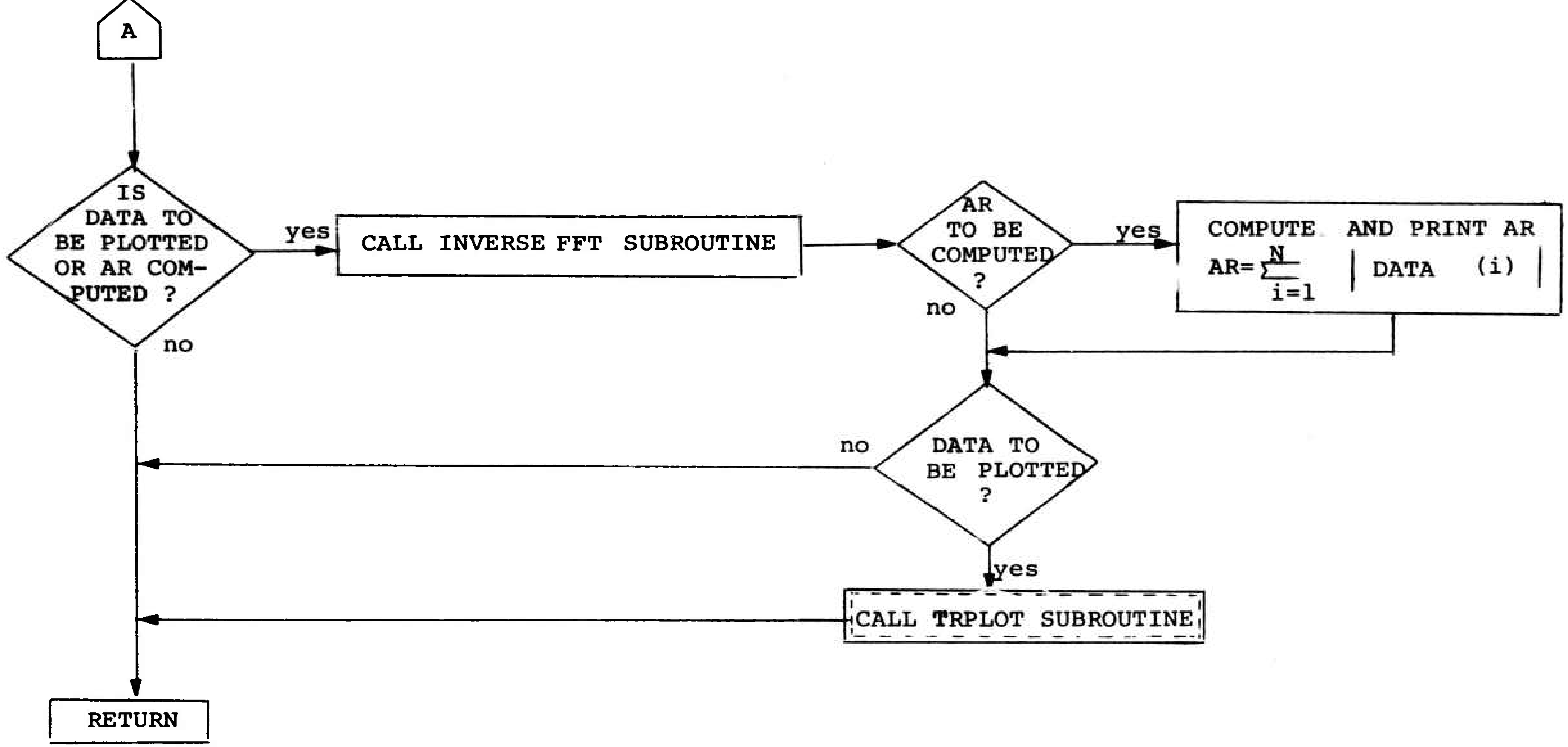


FIGURE III-6 (Cont'd)
PROCESS BEAMS
BEAMAN BMPROS

PAGE 2 OF 2 PAGES

Also, the improvement of the spectra over the reference spectra may be computed and plotted. If desired, the data are inverse transformed and AR is recomputed and the time domain trace is Calcomp plotted.

After processing all desired beams for an event, the main program returns to the event initialization subroutine and reads the next data card. This card tells the program to either begin processing the next event or to terminate processing.

2. Noise Analysis

The purpose of the noise analysis package, NOISAN, is to analyze the ALPA noise data by interrogating the noise crosspower spectral (CPS) matrices generated by the noise package. Optional analysis includes power spectra, channel equalization summaries, two channel and multiple coherences, and high resolution or conventional frequency-wavenumber (f-k) spectra. The general processing flow for NOISAN is shown in Figure III-7.

Program initialization is done by subroutine INEVPR (Figure III-8). This subroutine reads and checks the input data cards which specify the functions to be performed and the channels to be used in the processing.

Most of the matrix manipulation and reformating is performed by the subroutine ANALIN, shown in Figure III-9. ANALIN provides overlapped processing and I/O by double buffering the matrix storage area. Average power spectra for each component are taken from the annotation portion of the input record and saved for later display, if specified. Channel equalization of the CPS matrix can be performed; the channel equalization weights Ai(f) are given by:

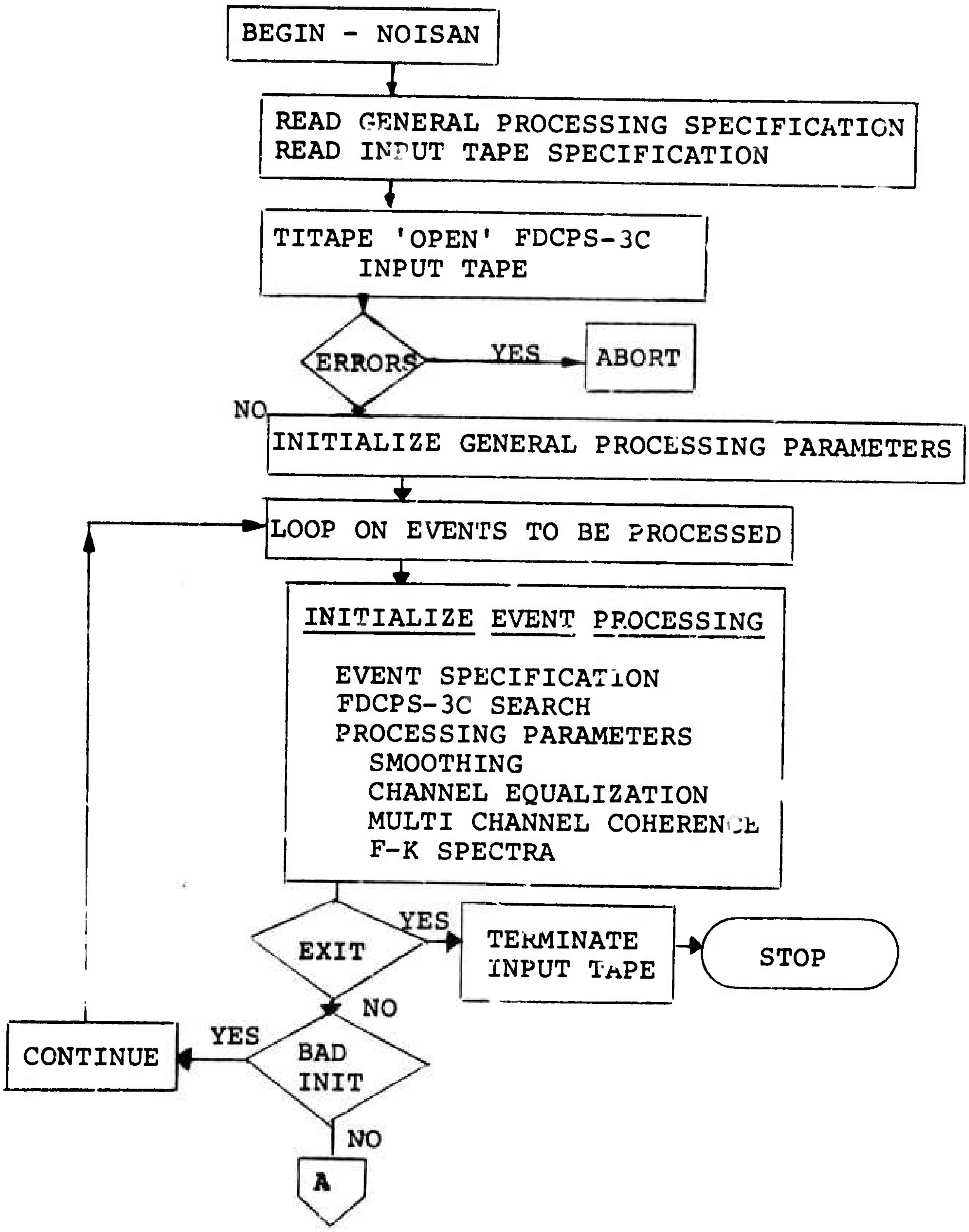


FIGURE III-7

NOISAN GENERAL FLOW
PAGE 1 OF 2 PAGES

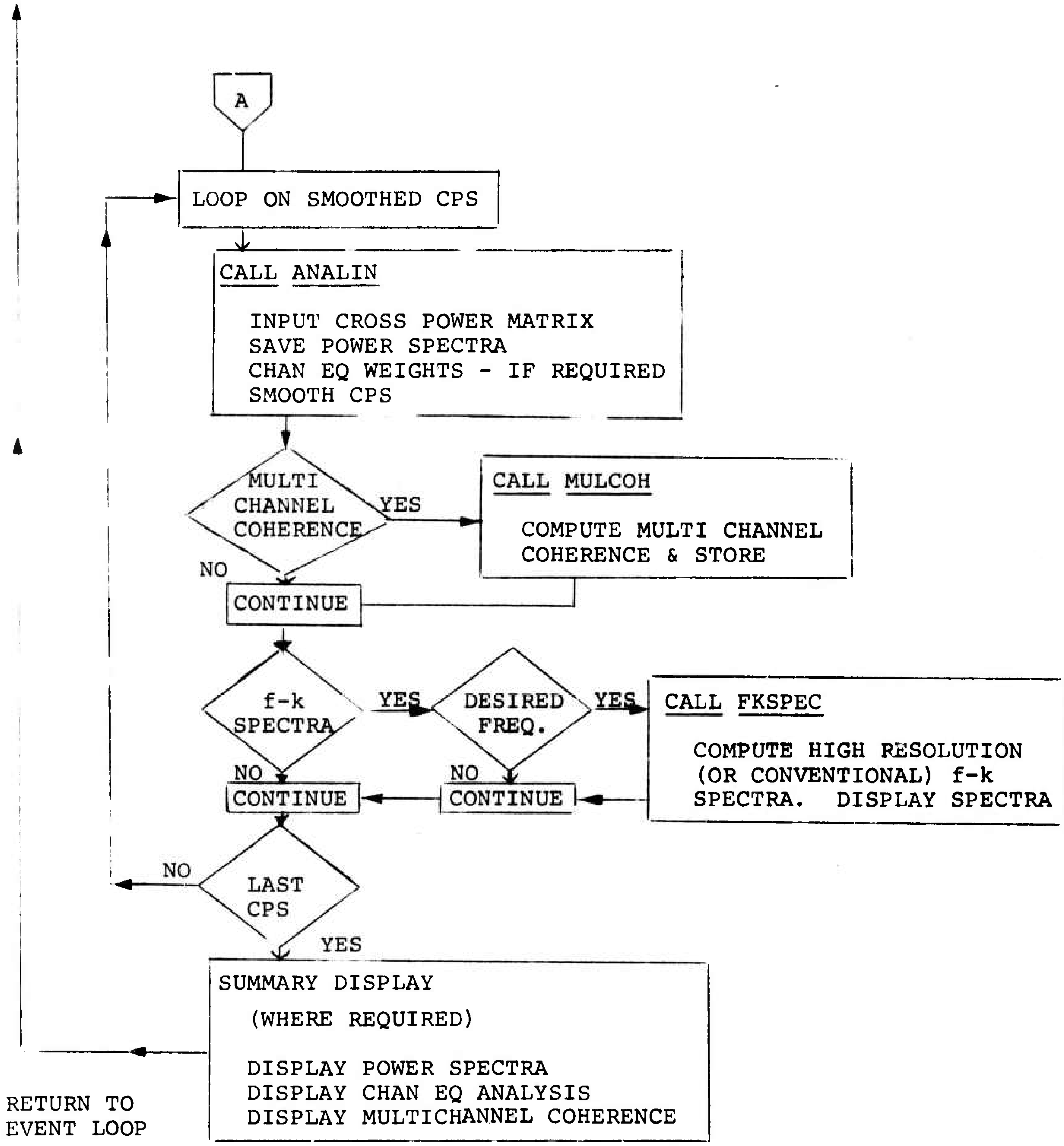


FIGURE III-7 (Cont'd)

NOISAN GENERAL FLOW
PAGE 1 OF 2 PAGES

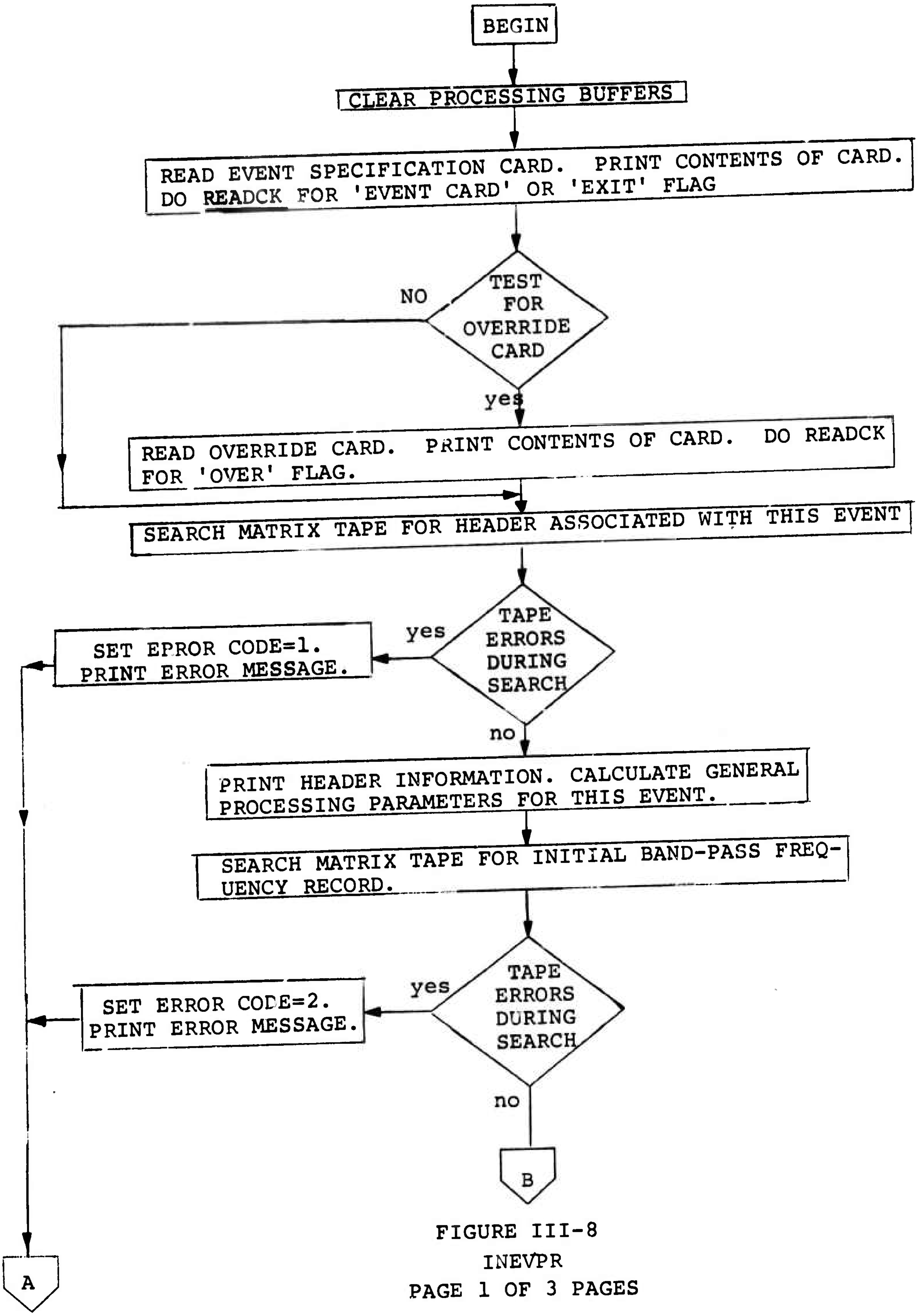


FIGURE III-8
INEVPR
PAGE 1 OF 3 PAGES

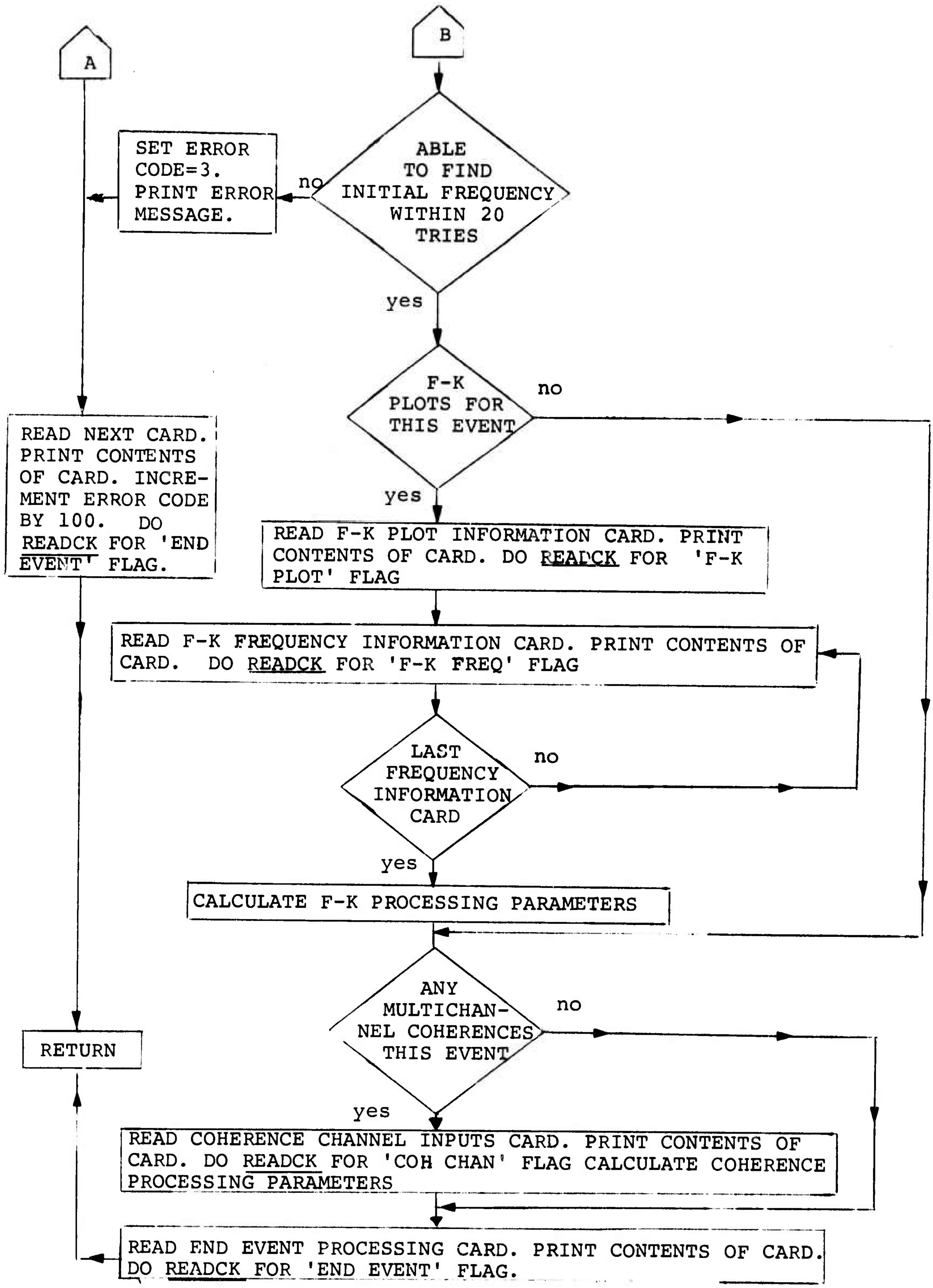
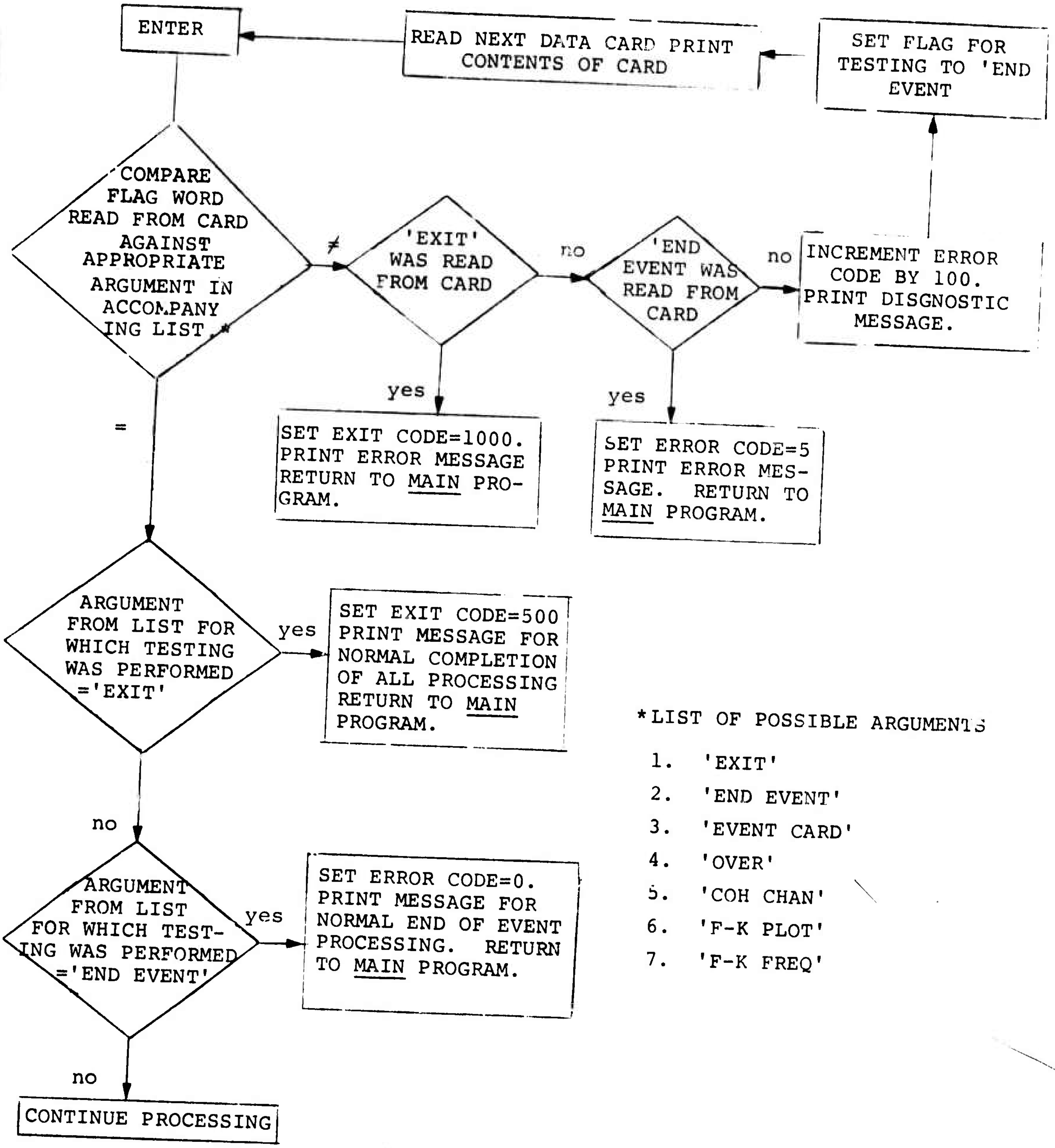


FIGURE III-8 (Cont'd)
INEVPR
PAGE 2 OF 3 PAGES



*LIST OF POSSIBLE ARGUMENTS

1. 'EXIT'
2. 'END EVENT'
3. 'EVENT CARD'
4. 'OVER'
5. 'COH CHAN'
6. 'F-K PLOT'
7. 'F-K FREQ'

FIGURE III-8 (Cont'd)
READCK (CALLED BY INEVPR)
PAGE 3 OF 3 PAGES

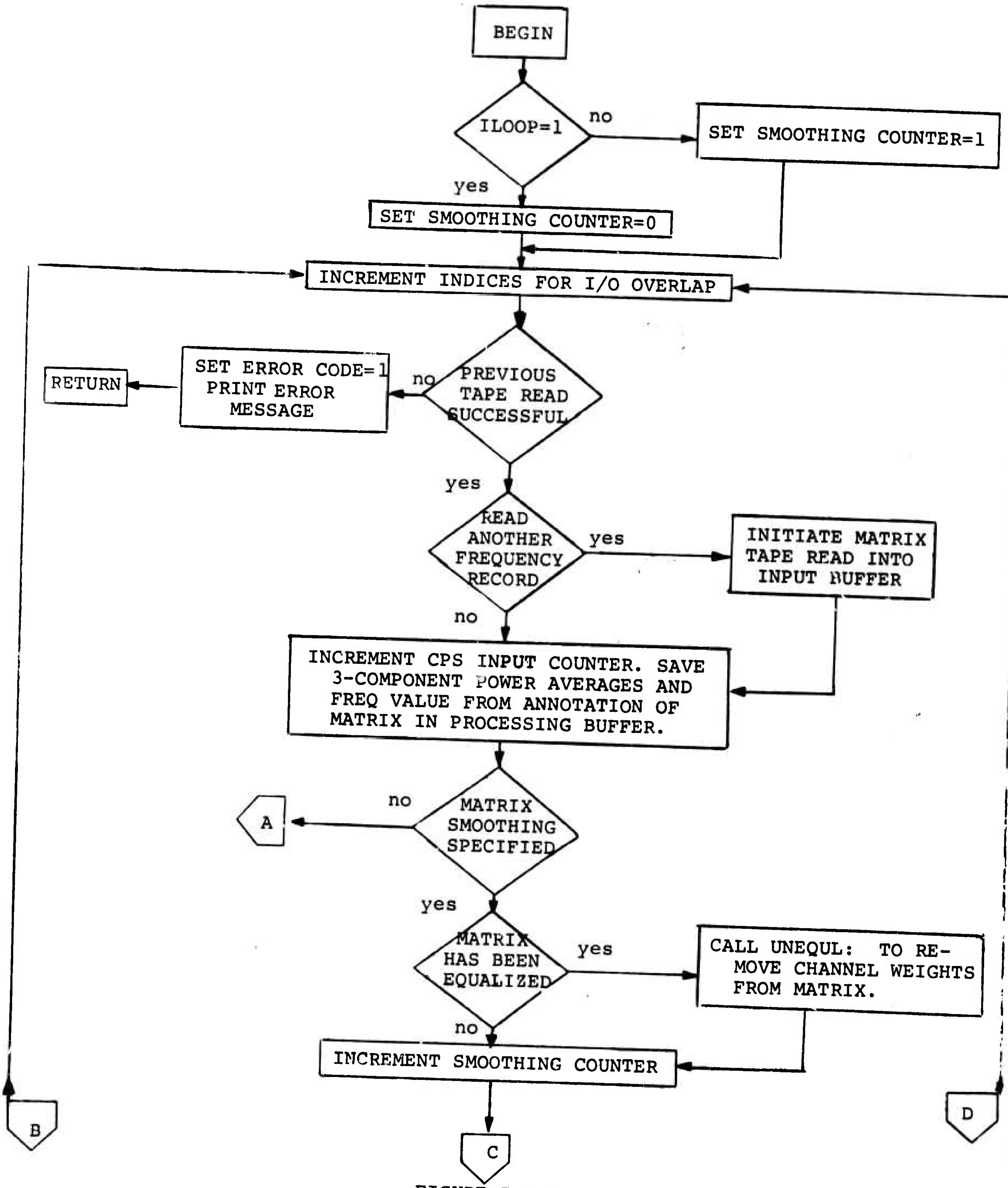


FIGURE III-9
ANALIN
PAGE 1 OF 5 PAGES

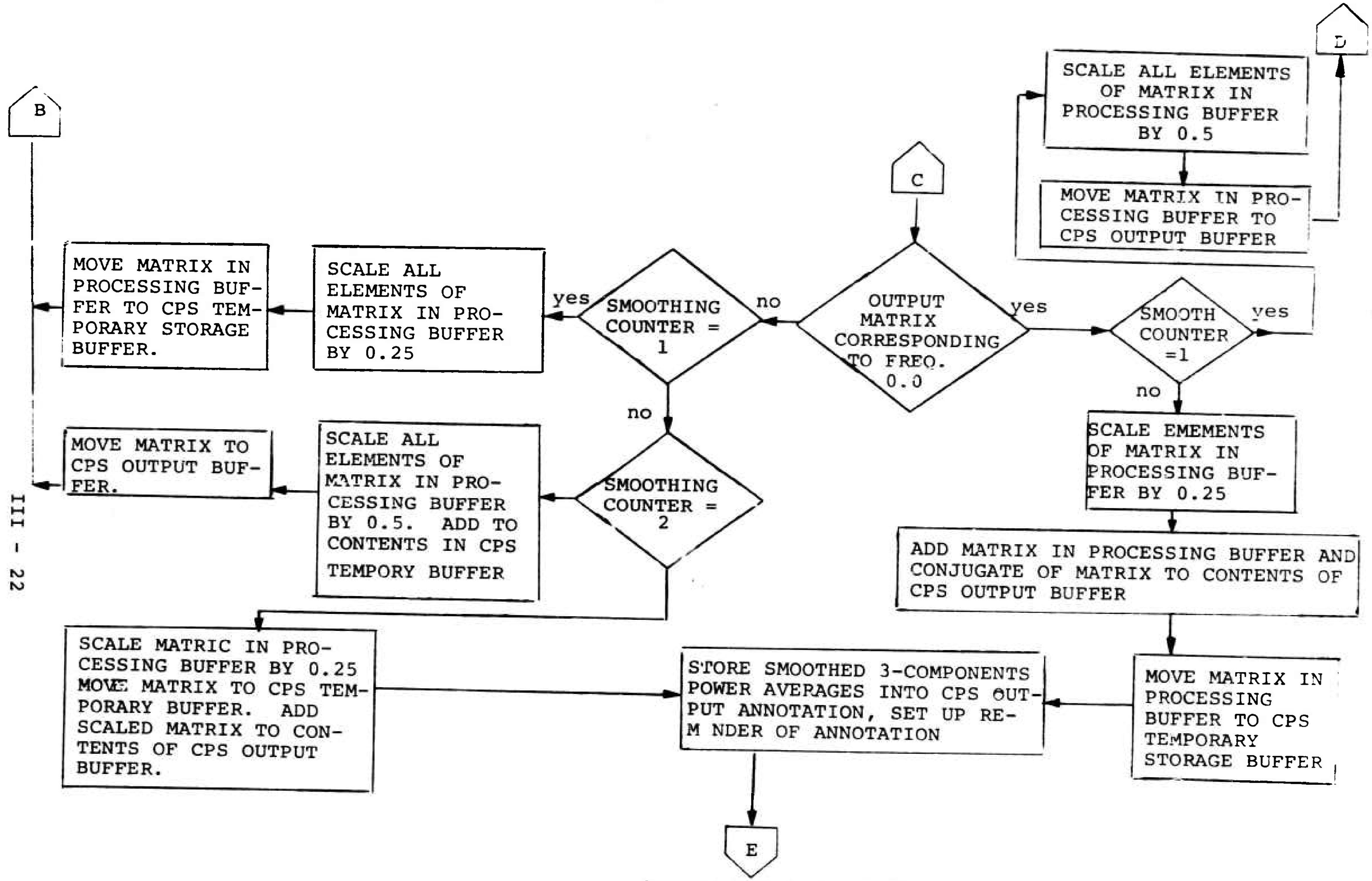


FIGURE III-9 (Cont'd)
ANALIN

PAGE 2 OF 5 PAGES

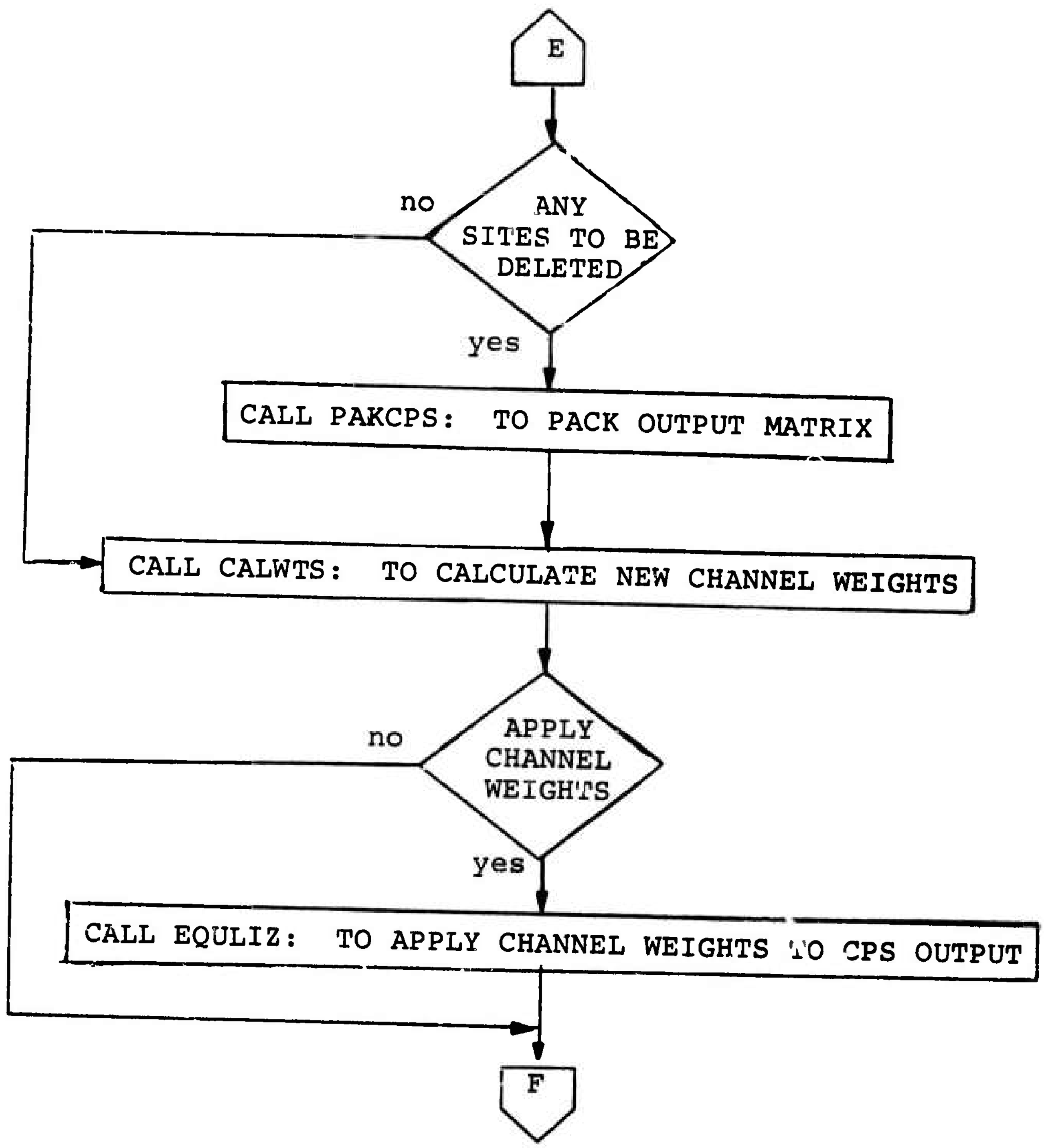


FIGURE III-9 (Cont'd)

ANALIN
PAGE 3 OF 5 PAGES

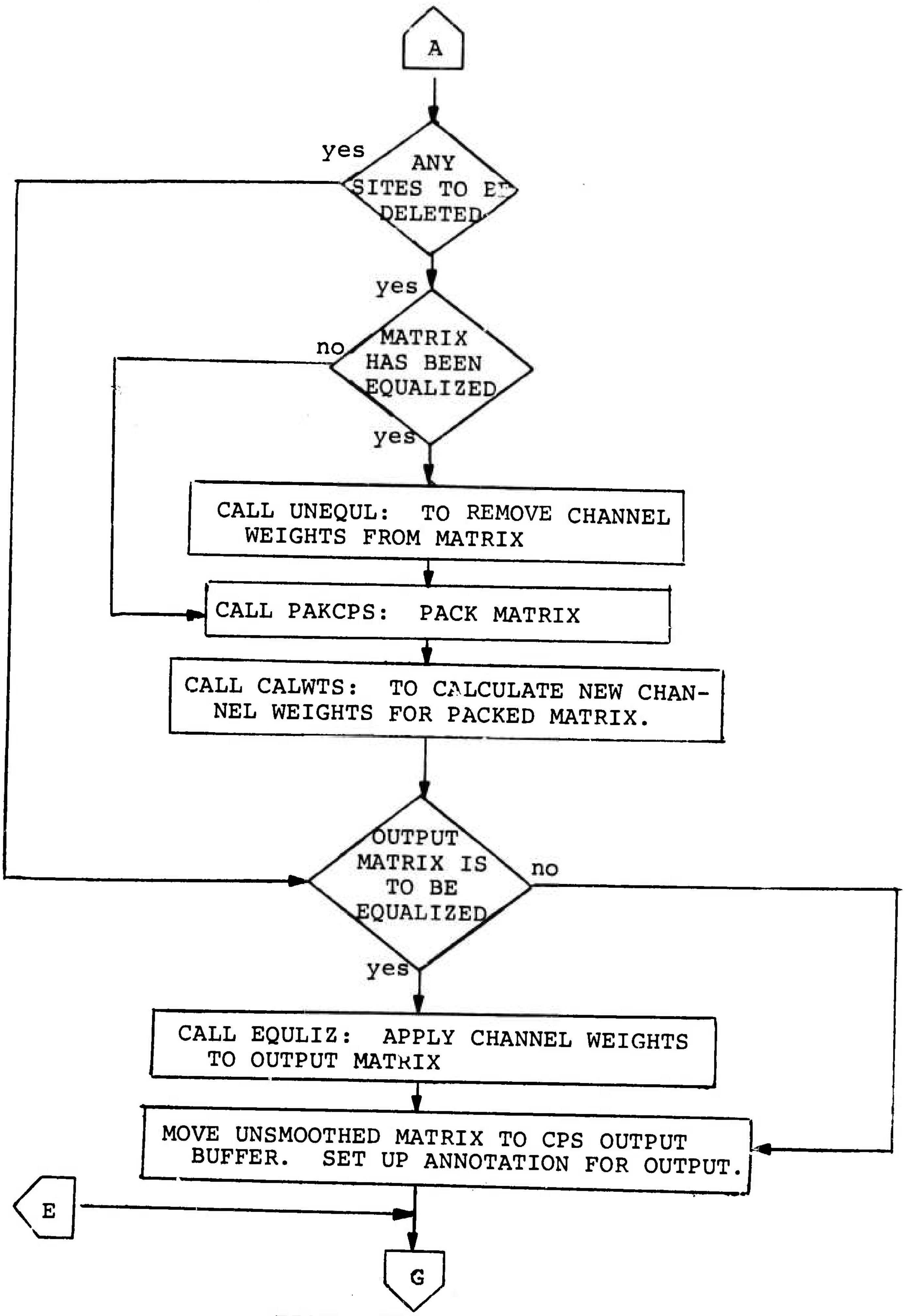


FIGURE III-9 (Cont'd)
ANALIN

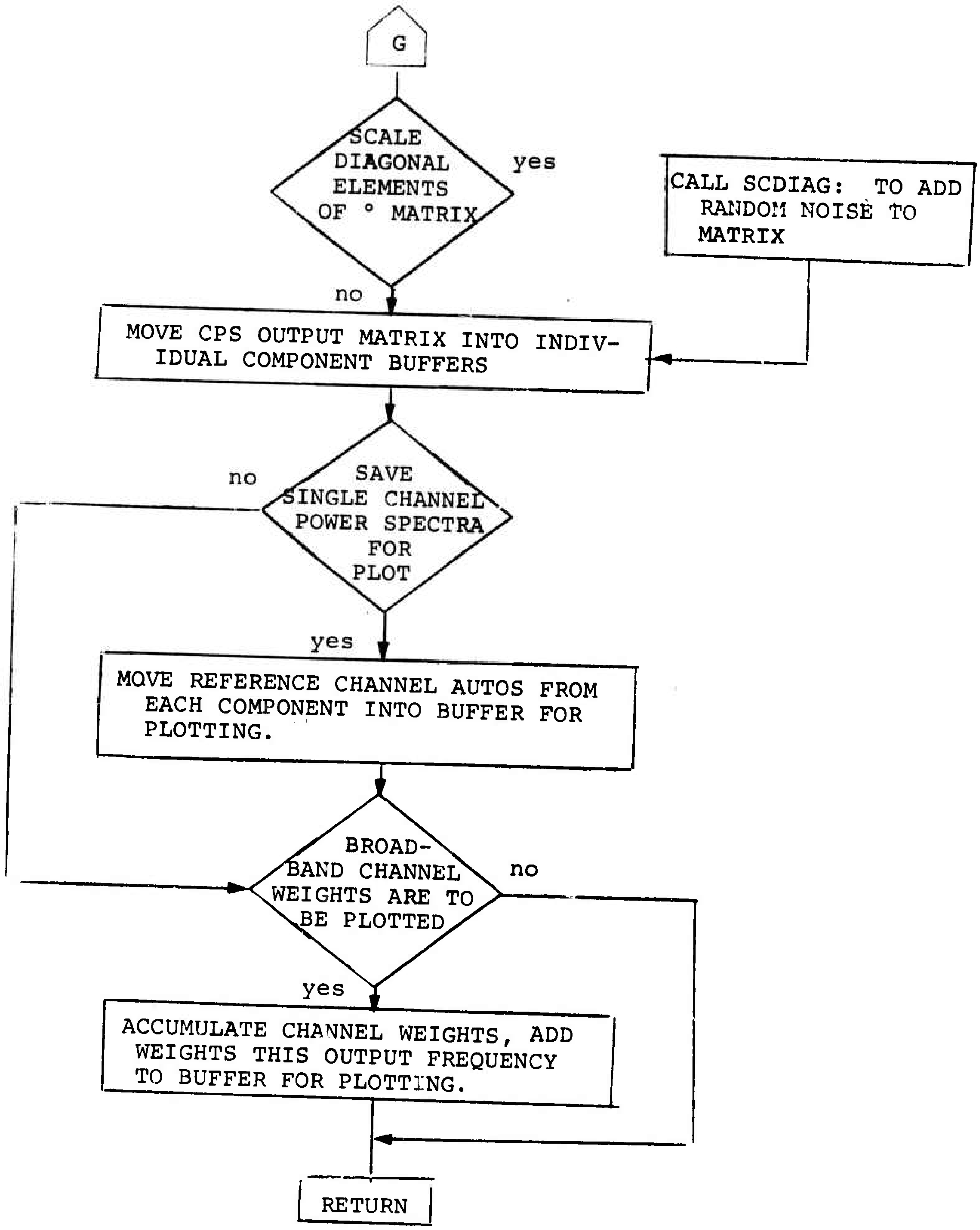


FIGURE III-9 (Cont'd)
ANALIN

PAGE 5 OF 5 PAGES

$$Ai(f) = \left[\frac{1}{NCHAN} \sum_{j=1}^{NCHAN} \frac{\Phi jj(f)}{\Phi ii(f)} \right]^{1/2}$$

Where: NCHAN is the number of channels in the matrix .
$\Phi ii(f)$ is the value of the autopower spectrum on channel i at frequency f.
$\Phi jj(f)$ are the values of the autopower spectra on channels j at frequency f.

An element of the equalized matrix $\Phi ij'(f)$ is then given by

$$\Phi'_{ij}(f) = Ai(f)\ Aj(f)\ \Phi_{ij}(f)$$

The reverse procedure can be used to remove channel equalization weights if they were applied in the noise package.

Broadband channel equalization weights are accumulated by averaging over all frequencies processed. These data can be plotted on the line printer if desired.

Matrix smoothing also is performed in ANALIN, where a smoothed element $\Phi_{ij}(f)$ is given by:

$$\Phi_{ij}(f) = \frac{1}{4}\ \Phi_{ij}(f-1) + \frac{1}{2}\ \Phi_{ij}(f) + \frac{1}{4}\ \Phi_{ij}\ (f+1)$$

Finally ANALIN adds spatially random noise to the CPS matrix (if desired) by scaling up the diagonal elements. The amount of random noise is specified by input cards.

Multiple coherences are computed by the subroutine MULCOH (Figure III-10). Channels to be used for each coherence calculation are specified by input cards; the first channel in each group is taken as reference. Up to 10 coherences can be computed for each component on one pass of the program.

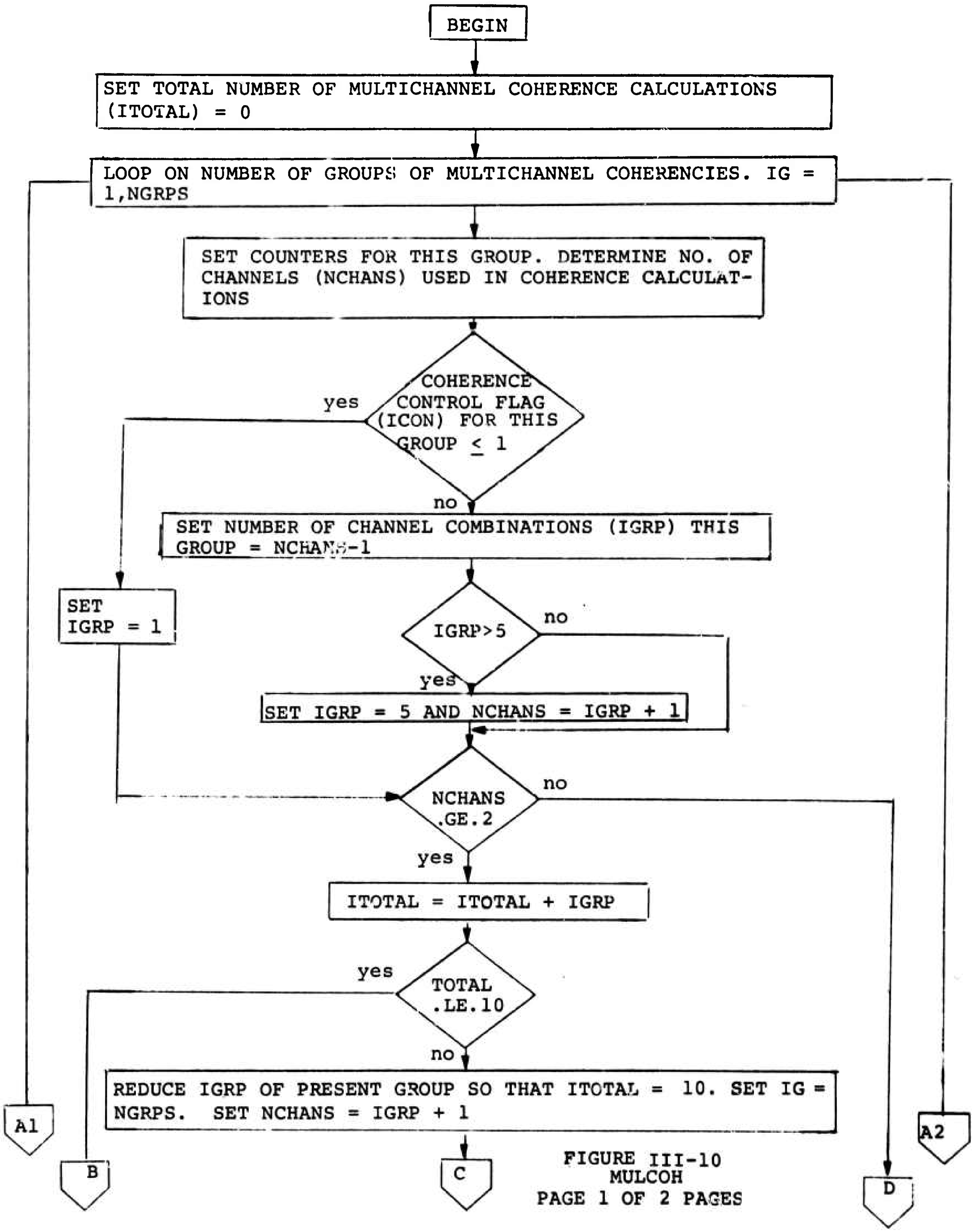


FIGURE III-10
MULCOH
PAGE 1 OF 2 PAGES

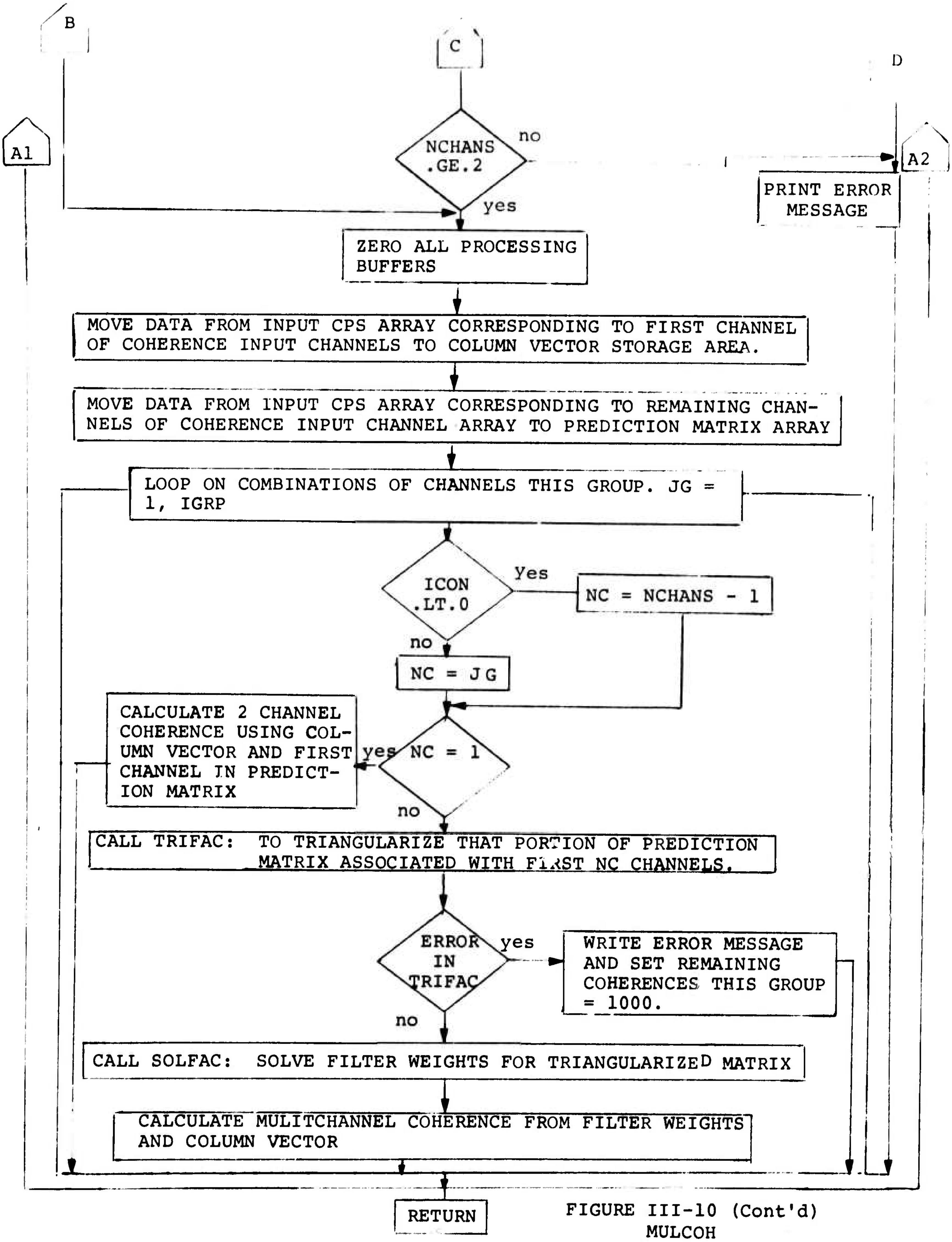


FIGURE III-10 (Cont'd)
MULCOH
PAGE 2 OF 2 PAGES

Frequency-wavenumber spectra are computed by the routine FKSPEC (Figure III-11). We define the vector [V] for each point $\vec{K}$ in wavenumber space. An element of [V] is given by

$$V_i = \frac{1}{N} \exp\left\{ -i2\Pi\vec{k}.\vec{X}_i \right\}$$

Where: N is the number of channels
$\vec{X}_i$ is the vector location of the sensor i relative to a reference location $\vec{X}_0$

Then the conventioned f-k spectrum is given by

$$CS(\vec{k}) = V^H \Phi V$$

Where: Φ is the noise CPS matrix
V^H is the congugate transpose of V

The high resolution f-k spectrum is given by

$$HRS(k) = \frac{1}{V^H \Phi^{-1} V}$$

The calculation is repeated at each value of $\vec{k}$ desired (for a given frequency). In practice, calculations are made using a regular grid in the wavenumber plane out to a minimum velocity specified by input card (VMIN).

In calculating high resolution spectra, matrix inversion is omitted by triangularizing the input CPS matrix and solving the Bryn filter set. The power value for a given point in wavenumber space is then the dot product between the phase vector for that point and the filter. Matrix triangularization is also performed for conventional spectra to speed the pre-and post-mulitplication by phase vectors.

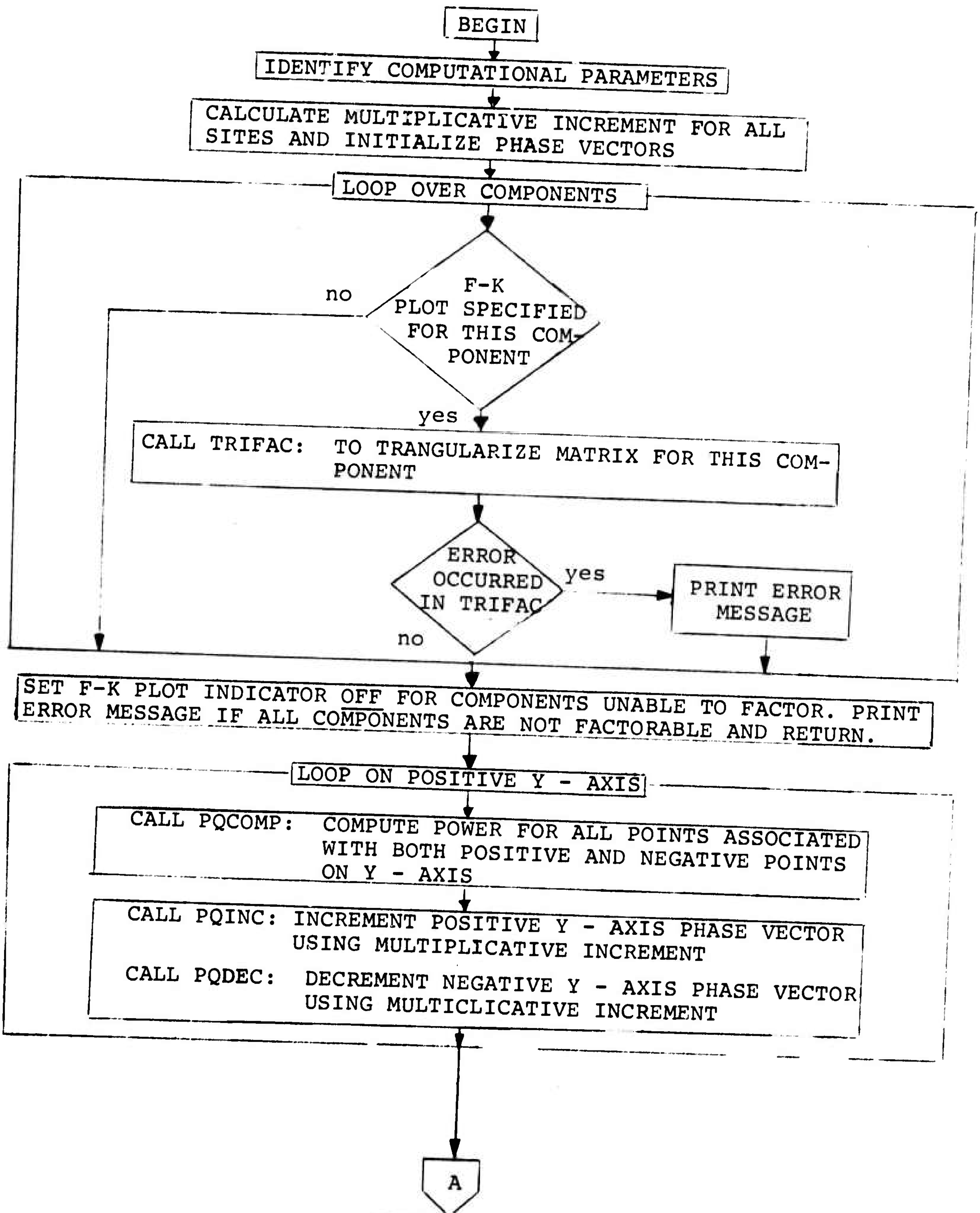


FIGURE III-11
FKSPEC
PAGE 1 OF 2 PAGES

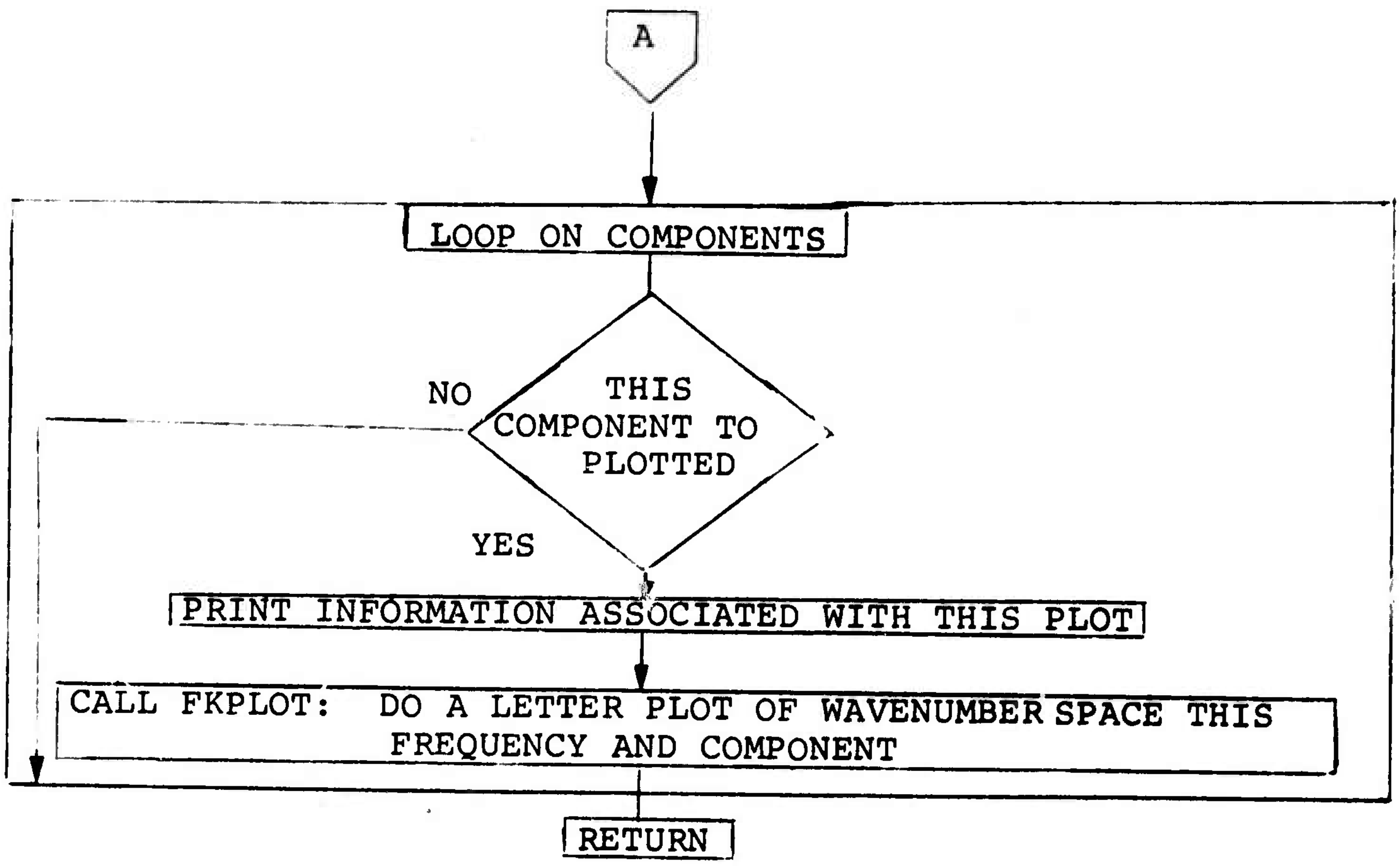


FIGURE III-11 (Cont'd)
FKSPEC
PAGE 2 OF 2 PAGES

Calculations are begun for the value $\vec{k}=0$. Then $\vec{k}_x$ is incremented while $\vec{k}_y$ is set to zero until all points out to a value corresponding to VMIN have been computed. Then $\vec{k}_y$ is incremented and $\vec{k}_x$ calculations are repeated. This procedure continues until $\vec{k}_y$ reaches a value corresponding to VMIN.

Note that the vector [V] has symmetry such that the values in the third and fourth quadrants are complex conjugates of the values in the first and second quadrants. This symmetry is used to reduce computations associated with phase vector generation.

If more than one component is used the spectra are generated simultaneously to take computational advantage of the fact that the phase vectors are the same from component to component.

The value calculated for each $\vec{k}$ is converted to db and assigned a letter which indicates the difference between the peak spectral value and the value at $\vec{k}$. The letter display of the f-k spectra facilitates contouring, which is done by hand.

Output from NOISAN consists of printer plots of both component average power spectra and single channel reference spectra, dumps of broad-band channel weights in db, coherence plots, and wavenumber plots. All output with the exception of wavenumber plots is performed by the DSPLAY routine shown in Figure III-12.

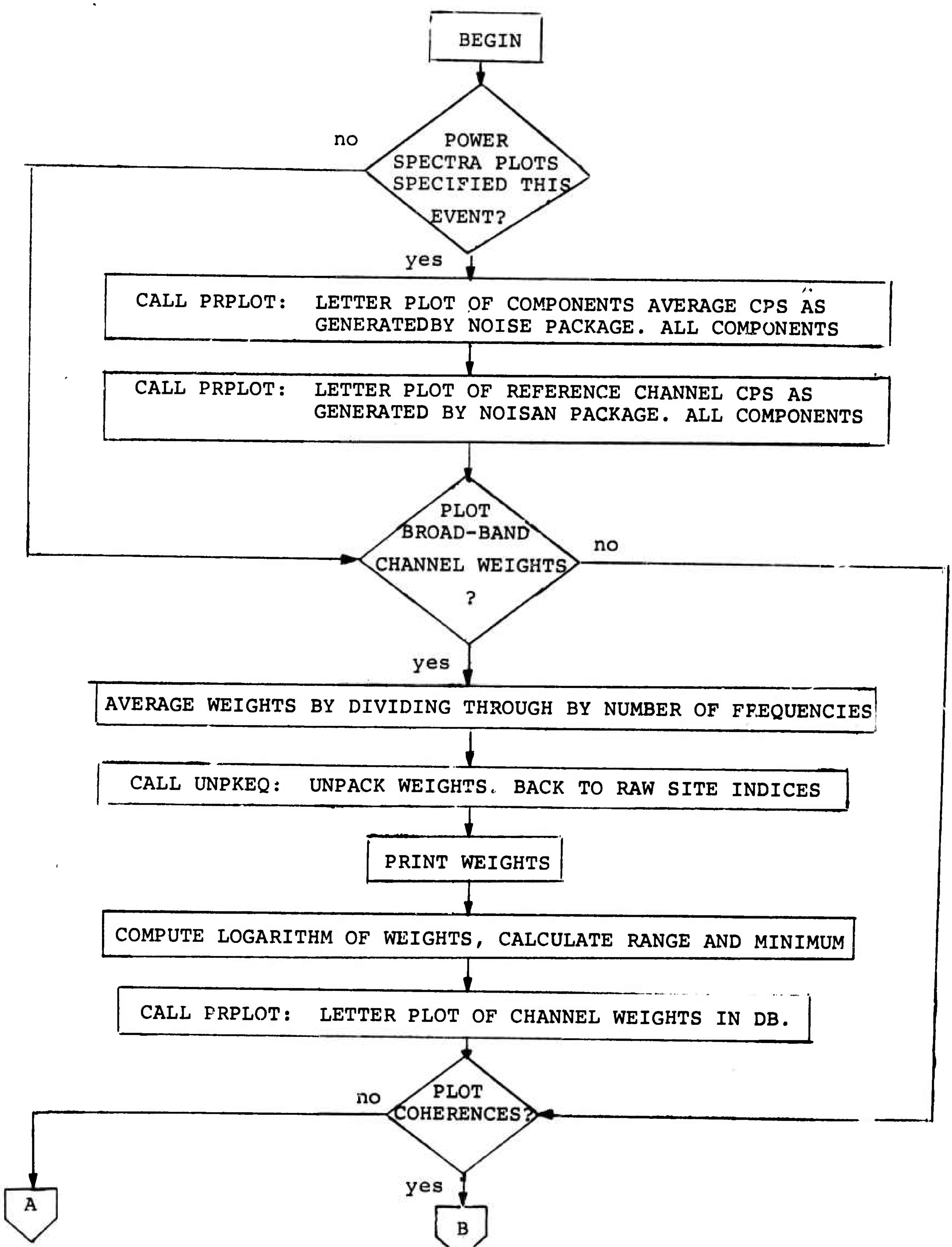


FIGURE III-12
DSPLAY
PAGE 1 OF 2 PAGES

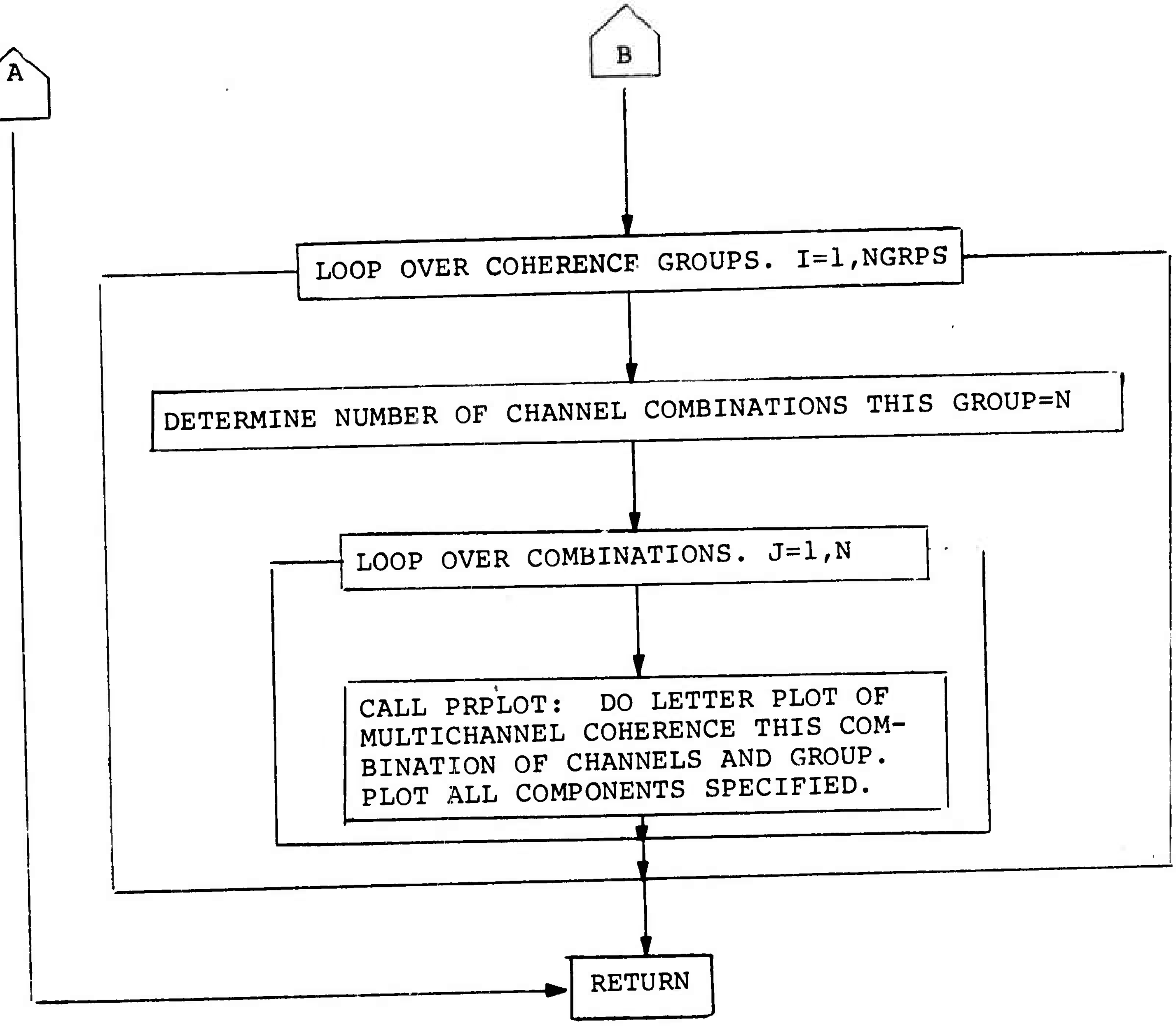


FIGURE III-12 (Cont'd)
DSPLAY

PAGE 2 OF 2 PAGES

3. Signal Analysis

The main purpose of the signal analysis program, SIGNAN, is to measure signal similarity across the array for each phase by computing the correlation coefficient. In general, large signals will be used to measure signal similarity. The general program flow is shown in Figure III-13.

The program executes in two phases: processing initialization, and a loop on events to be processed. Initialization is performed by subroutine PINIT (Figure III-14), which performs functions such as opening tapes and rewinding disks. The processing of each event consists of three main steps, each handled by a major subroutine.

Subroutine VINIT (Figure III-15) reads and checks input data cards which specify how the event is to be processed and sets up control parameters.

Subroutine PREPAR (Figure III-16) reads the required data from tapes and demultiplexes it to a series of disk files. Since the TDDATA format tapes contain the time domain data multiplexed by (POINTS, COMPONENTS, SITES, SEGMENTS), while the nature of computations requires that the data be in the form (POINTS, SEGMENTS, SITES, COMPONENTS), demultiplexing and data flow operations are a fundamental portion of the program. PREPAR reads the input tape in its original format (segment by segment) stores reference site data in core and outputs data to disk files.

Subroutine RELATE (Figure III-17) inputs the site data from the disk files and performs the signal similarity computations.

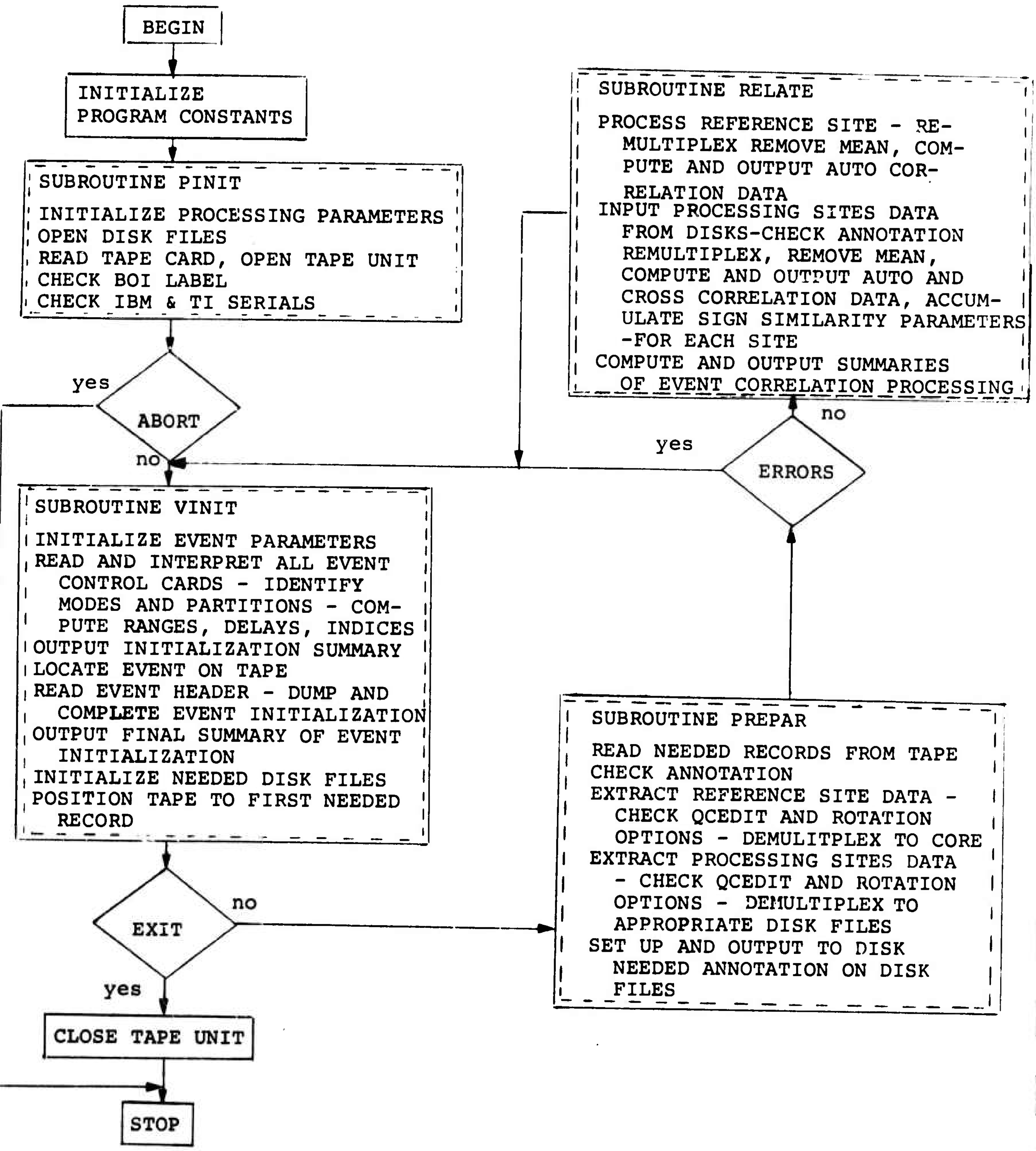


FIGURE III-13

SIGNAN GENERAL FLOW

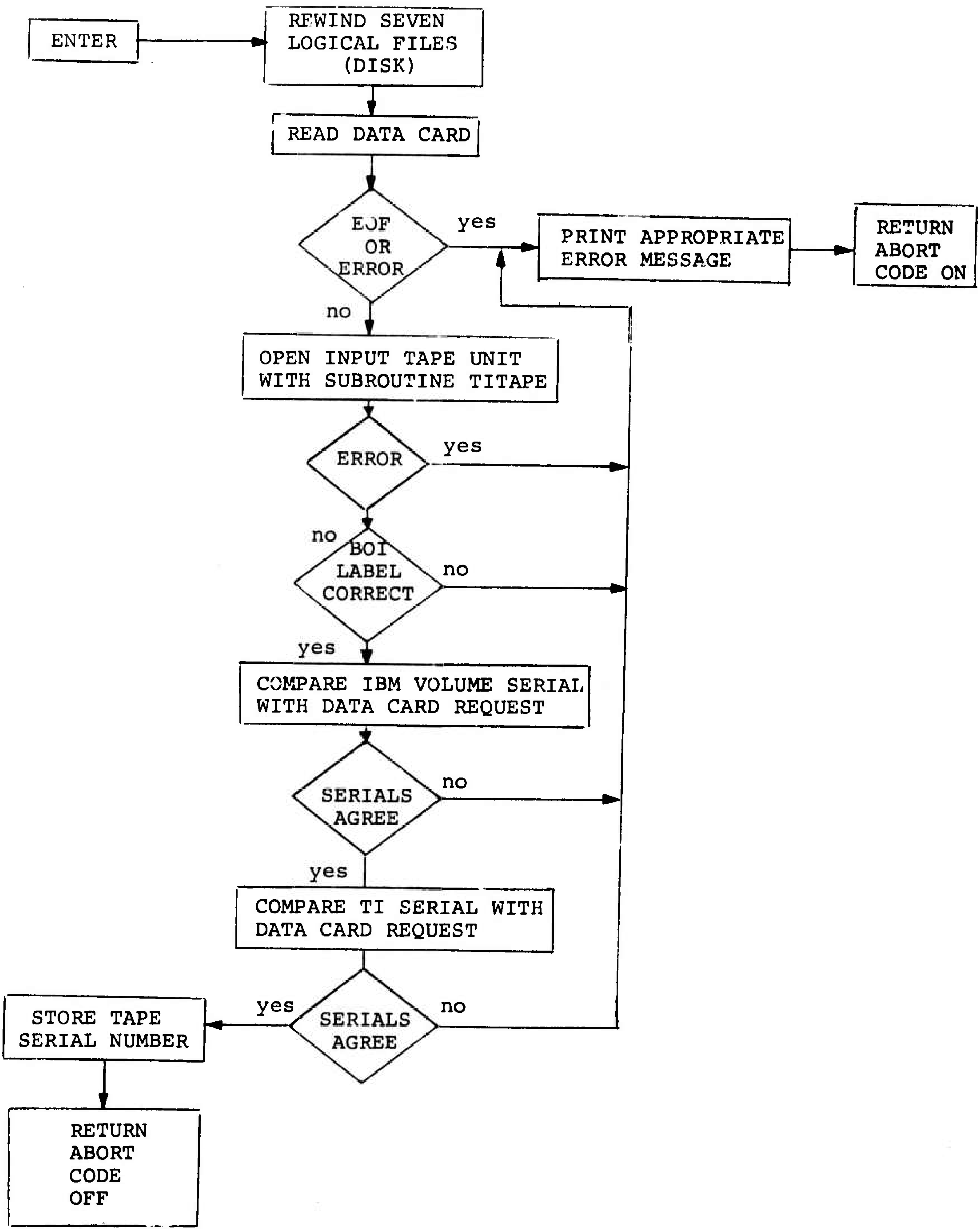


FIGURE III-14
PINIT

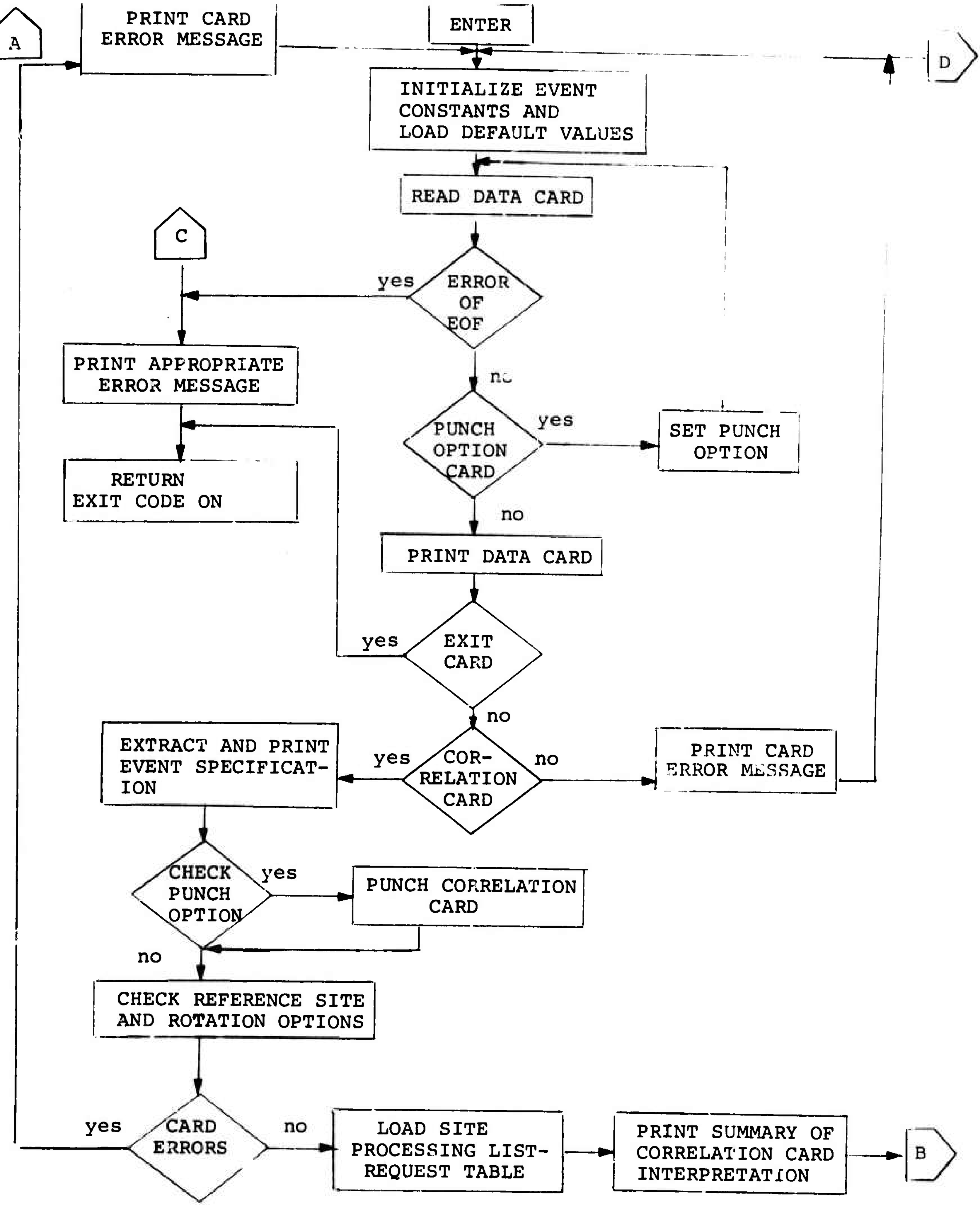


FIGURE III-15

VINIT
PAGE 1 OF 4 PAGES

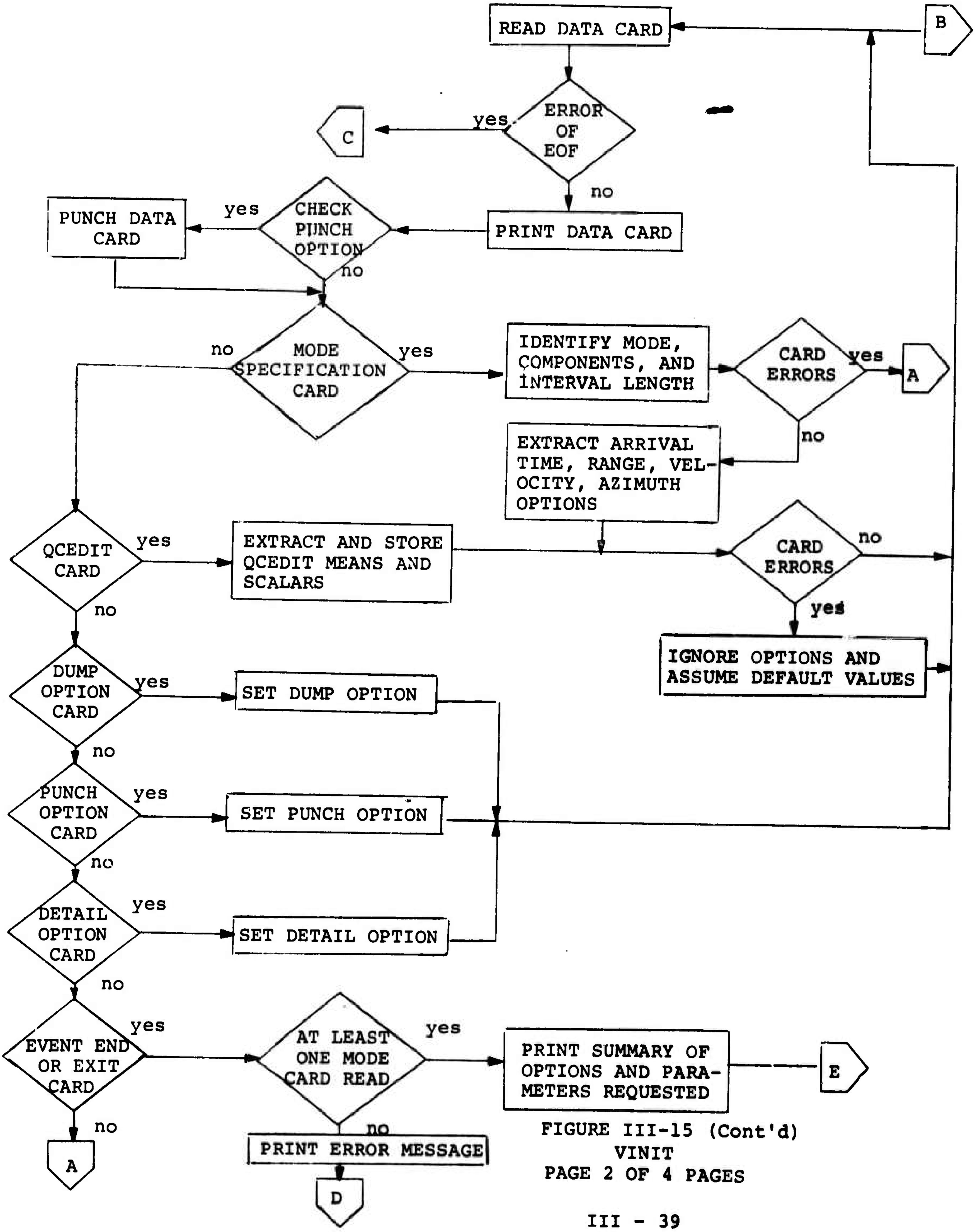


FIGURE III-15 (Cont'd)
VINIT
PAGE 2 OF 4 PAGES

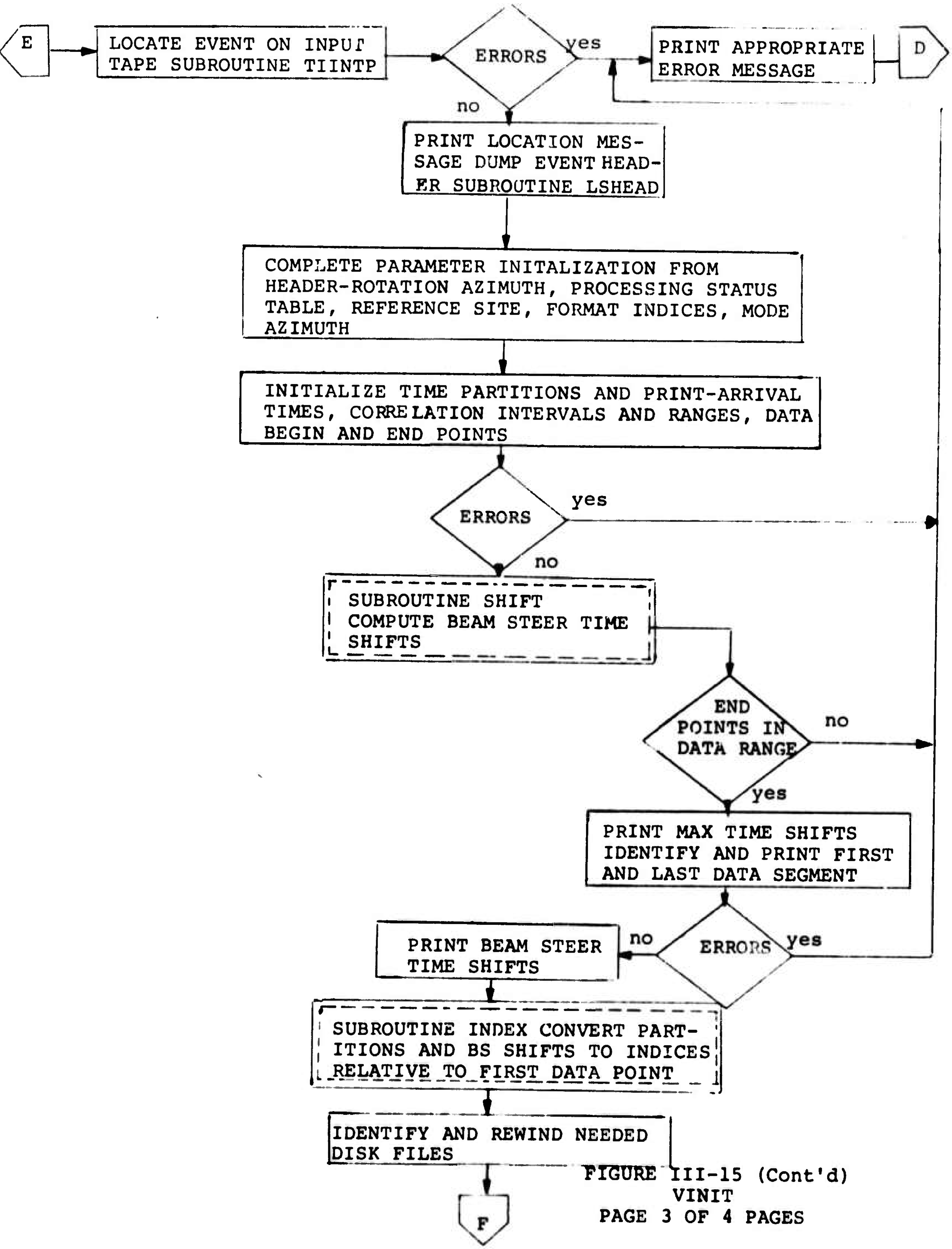


FIGURE III-15 (Cont'd)
VINIT
PAGE 3 OF 4 PAGES

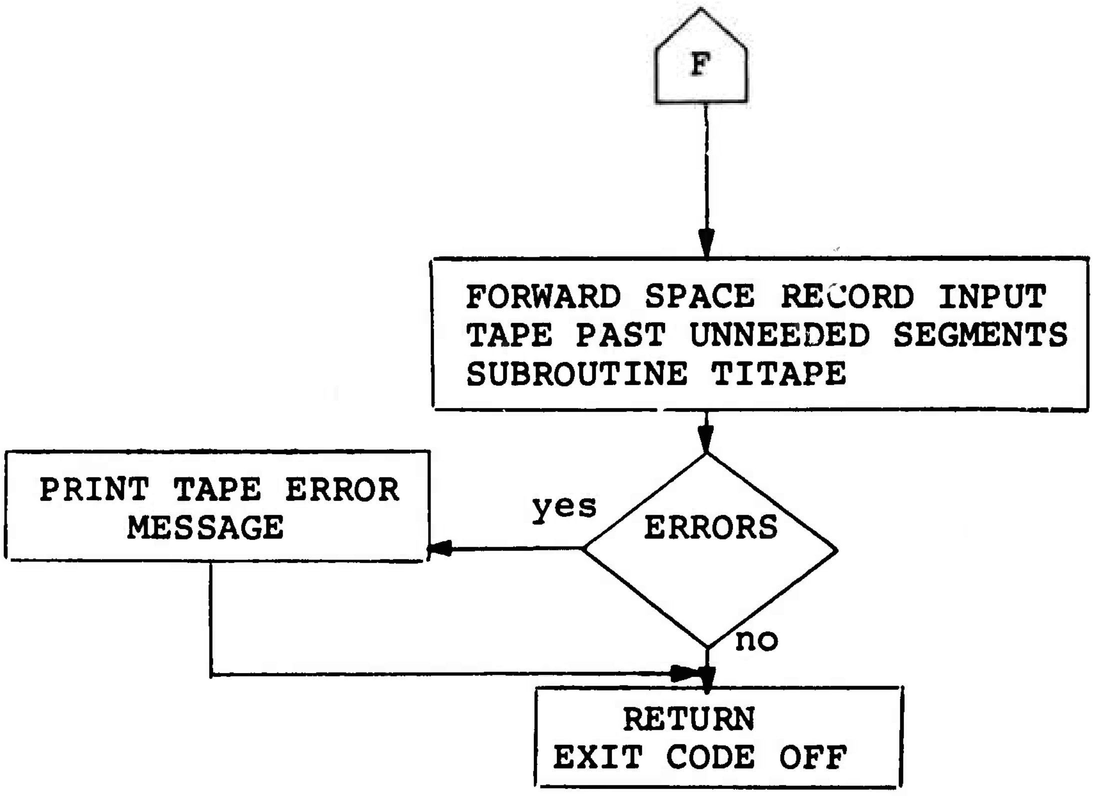


FIGURE III-15 (Cont'd)
VINIT

PAGE 4 OF 4 PAGES

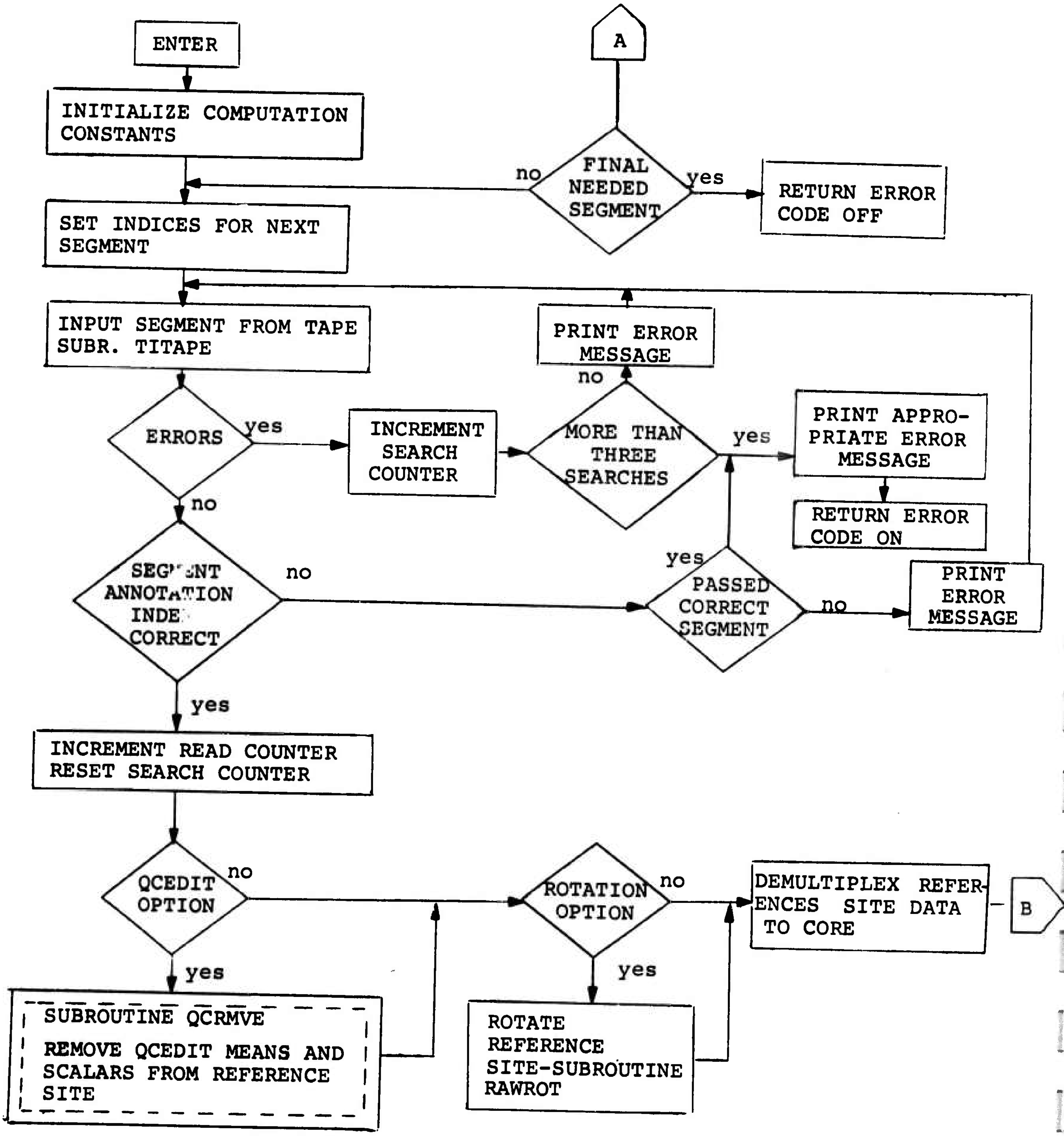


FIGURE III-16
PREPAR

PAGE 1 OF 3 PAGES

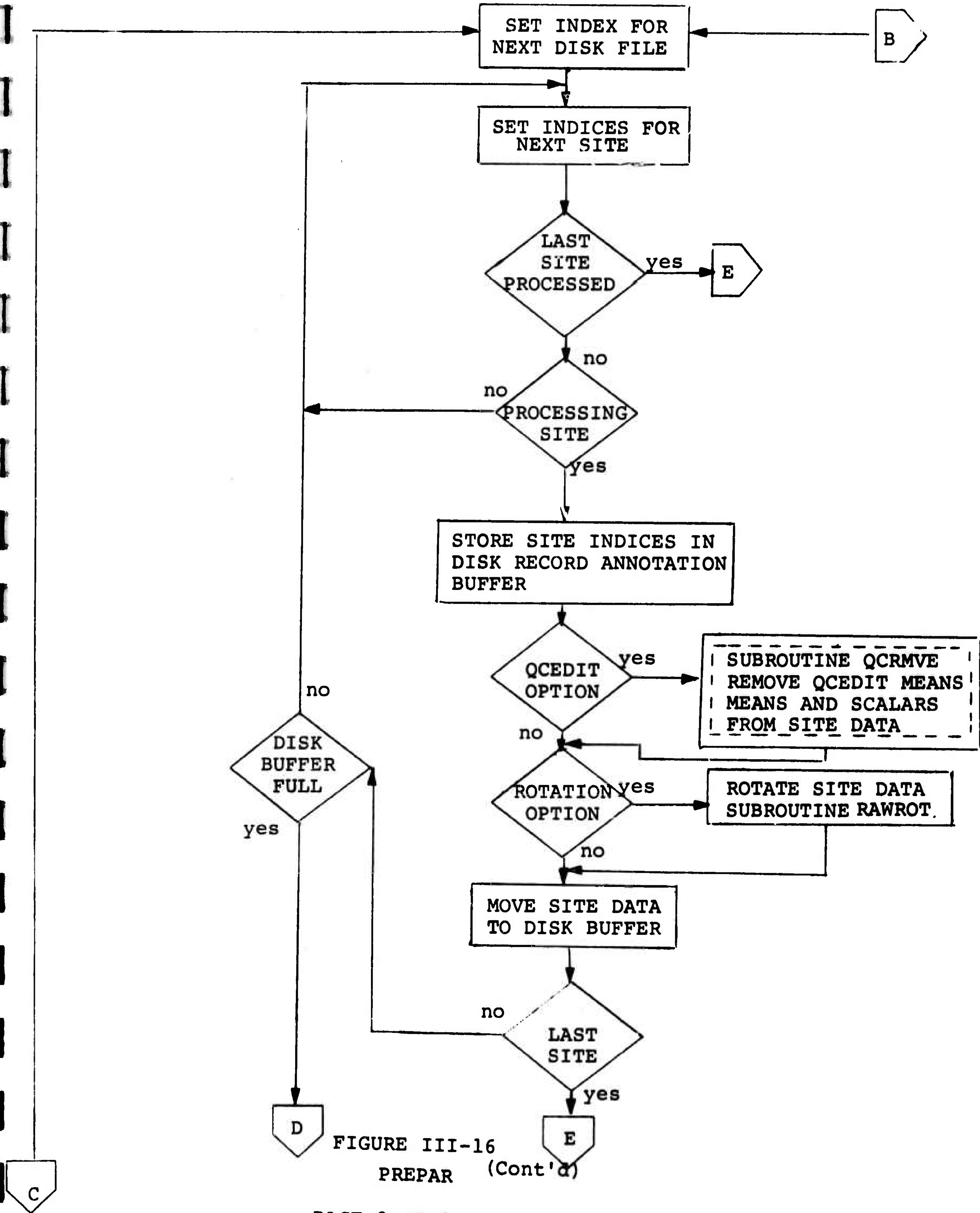


FIGURE III-16
PREPAR (Cont'd)

PAGE 2 OF 3 PAGES

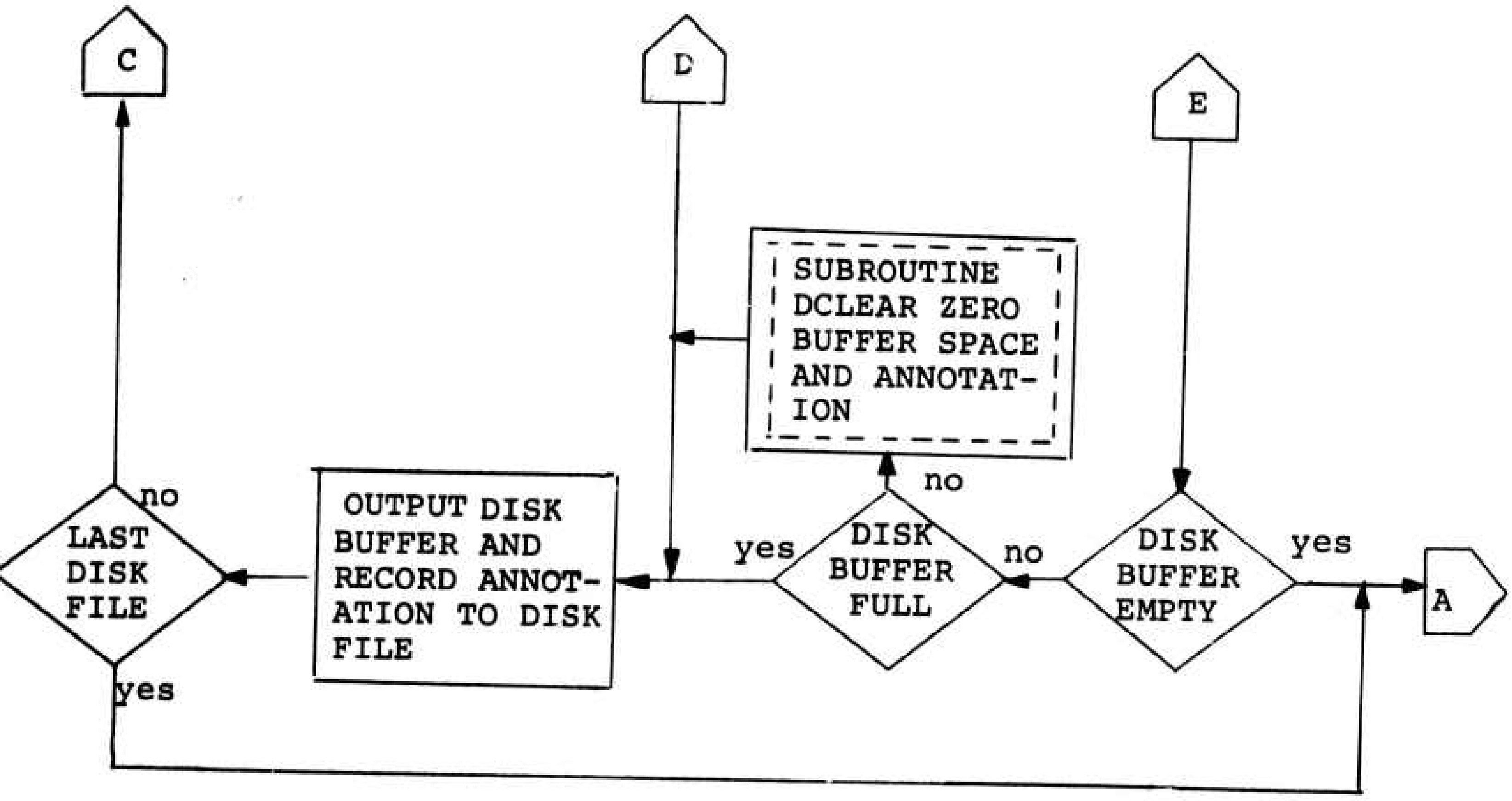


FIGURE III-16 (Cont'd)
PREPAR
PAGE 3 OF 3 PAGES

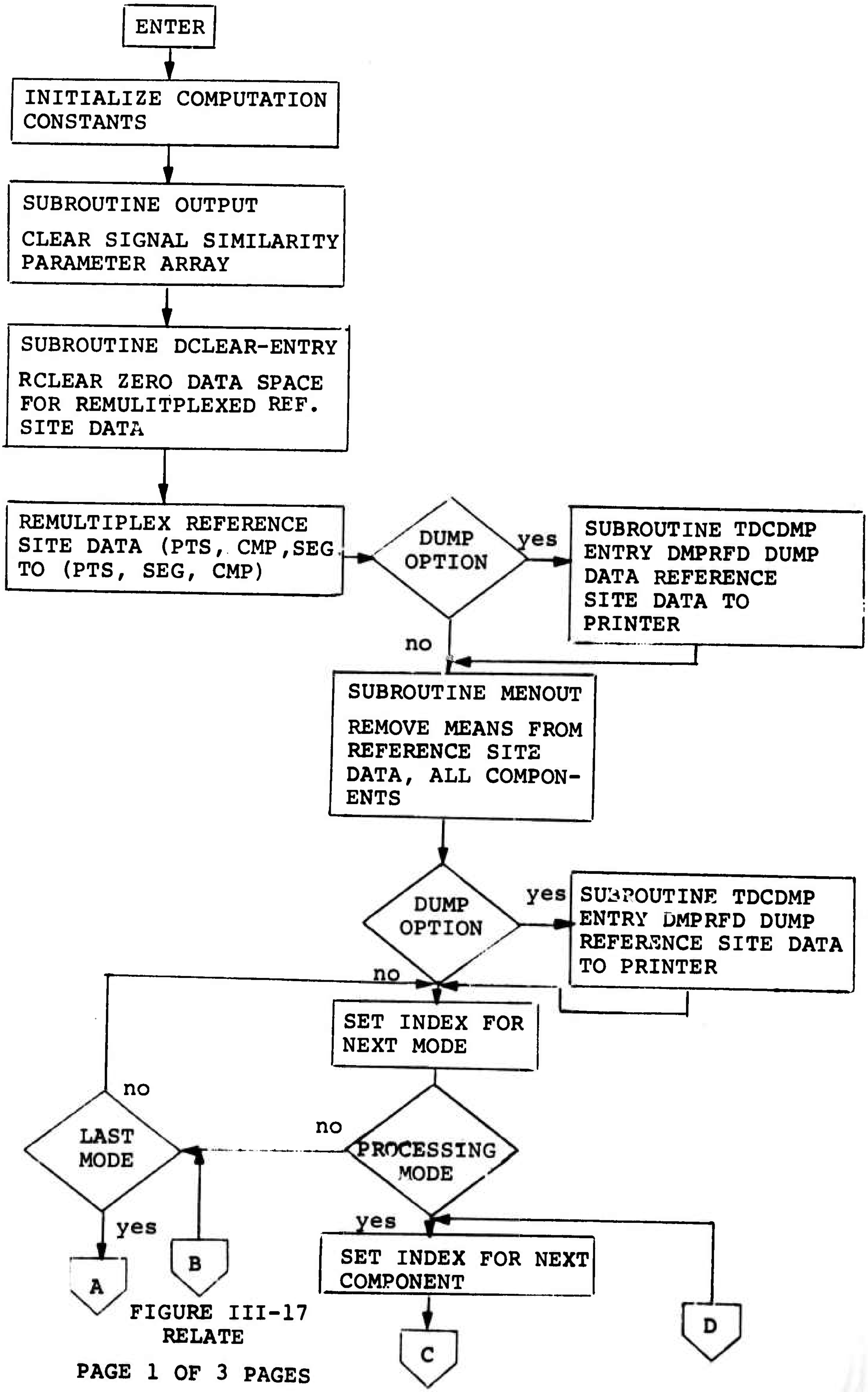


FIGURE III-17
RELATE

PAGE 1 OF 3 PAGES

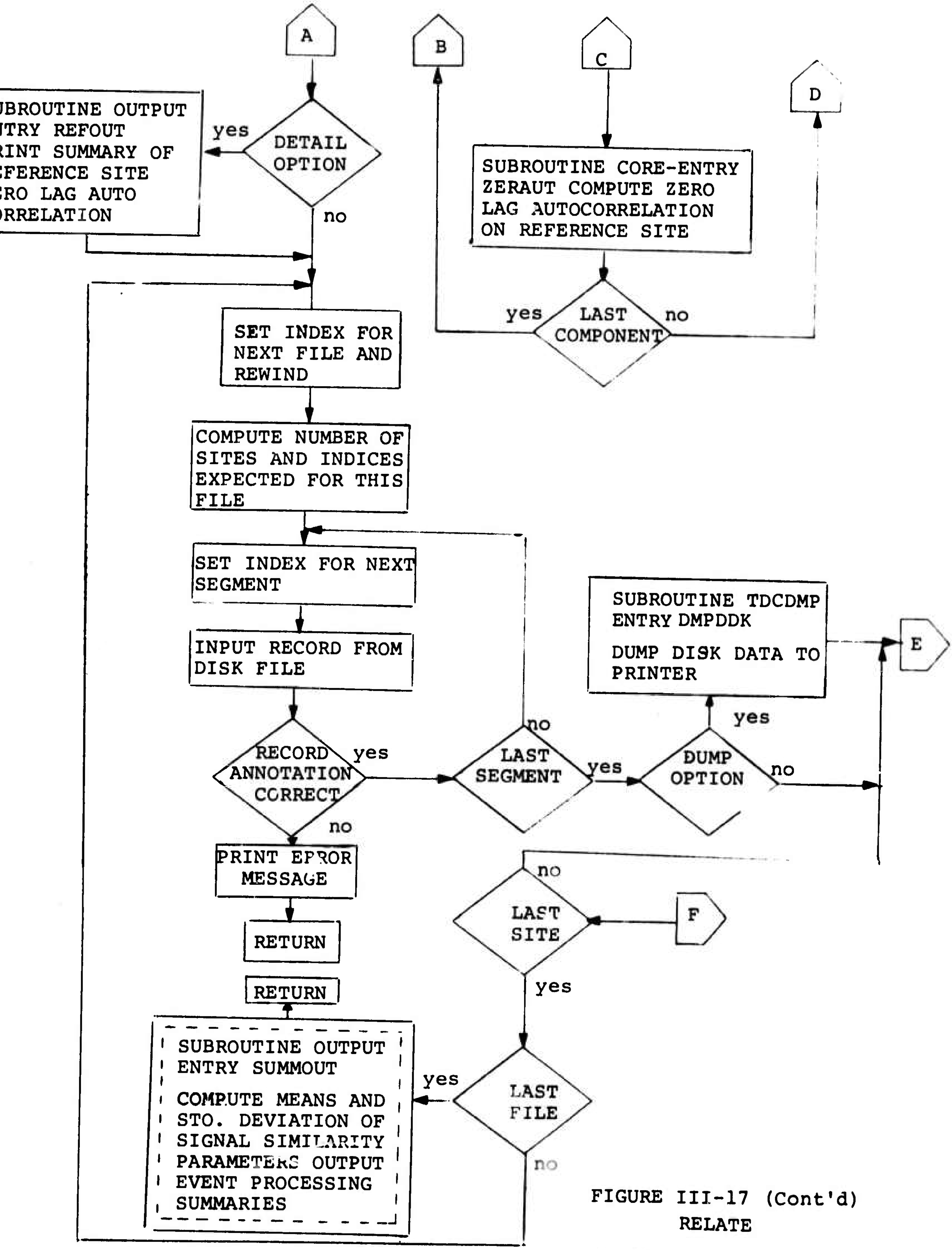


FIGURE III-17 (Cont'd)
RELATE

PAGE 2 OF 3 PAGES

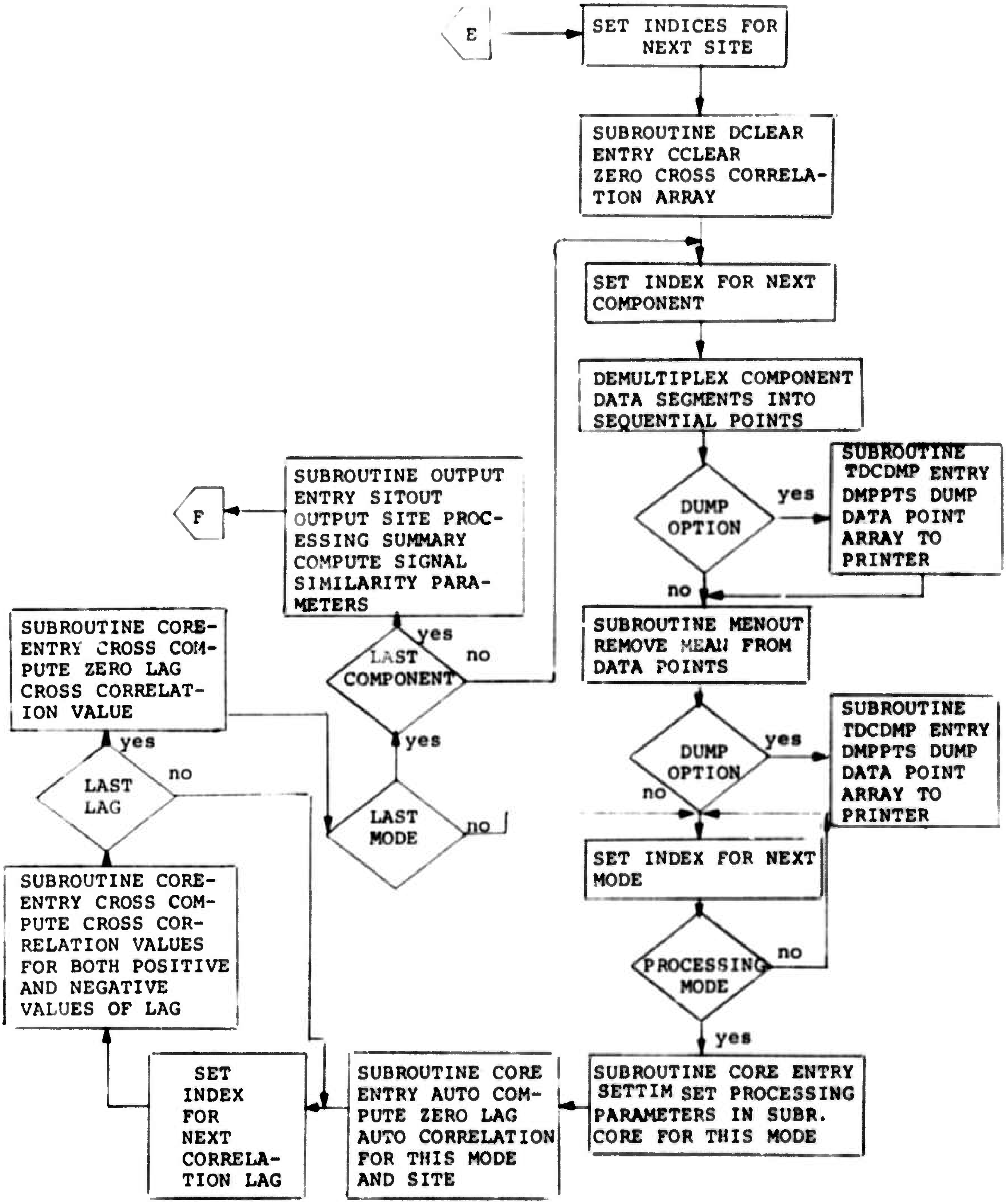


FIGURE III-17 (Cont'd) RELATE
PAGE 3 OF 3 PAGES

The correlation coefficient (C_{ri}) is defined as

$$C_{ri} = \frac{\Phi_{ri}\,(\tau_{max})}{[\Phi_{rr}(0)\,\Phi_{ii}(0)]^{\frac{1}{2}}}$$

Where: $\Phi_{ri}\,(\tau_{max})$ is the maximum value of the cross-correlation function between the reference and i^{th} site

$\Phi_{rr}(0)$, $\Phi_{ii}(0)$ are the zero-lag autocorrelation values for the reference and i^{th} sites

Before C_{ri} is computed the mean is removed from the traces and the traces are approximately aligned using the beam steer lag values for each site (relative to the reference site). These values can either be computed in the program by specifying a velocity and azimuth for the arrival of interest or taken from the header information associated with the event.

A starting time (K_1) and gate length (N) are specified for each phase; K_1 may be specified by input card or taken from the header information. Any or all sites may be used, up to a maximum of 22.

The crosscorrelation function is computed for lags from -25 to +25 and the maximum value is automatically selected by the program. Since the data are approximately time aligned before calculations are initiated, the maximum value usually occurs close to the zero-lag value. The lags at which the maximum value of the crosscorrelation occurs are saved for each site and will be used to study azimuthal anomalies (indicated by systematic variations) and deviation from plane-wave arrivals (indicated by random variations).

After processing of all sites is completed, correlation coefficient means and standard deviations are computed for each phase using the expression:

$$\overline{C} = \frac{1}{M} \sum_{i=1}^{M} C_{ri}, \text{ and } SD = \left[\frac{1}{M-1} \sum_{i=1}^{M} (C_{ri} - \overline{C})^2 \right]^{\frac{1}{2}}$$

where M is the number of data sites processed.

Program output is primarily to the printer, at three levels of detail. Basic output is a table of correlation coefficients and associated values of τ_{max} by site, phase, and component, with means and standard deviations. More detailed output includes auto and cross correlation for each data site. Finally, a dump option permits printout of the input data, demuliplexed data, and cross correlation arrays for each site processed. In all cases, data card interpretation, partitions, and initialization summaries are output. All options are event specific.

All error conditions are handled within the program. Errors in processing initalization will abort the run; any subsequent errors, such as mispunched data cards, will cause processing of that specific event to be deleted, and the next event begun. In all cases, appropriate messages are printed. Any number of events, on a given tape, may be processed any number of times. Exit from the processing loop is through an exit card or end of file condition at the card reader.

4. Tape Copy/Merge

This program, called TPCOPY, performs the functions of copying and merging information from off-line processing tape according to the user's specifications. Figure III-18 shows a general flow for the program.

The program executes in three stages; the main program reads and evaluates the specification cards. Control is passed to subroutine INITAP (Figure III-19), which gives tape mounting instructions to the operator and prepares the input and output tapes. The subroutine EXCOPY (Figure III-20) then performs the actual copy merge task.

TPCOPY performs its I/O functions primarily by the usage of the off-line subprograms TITAPE and STATUS described in previous quarterly reports. In so doing TPCOPY takes advantage of TITAPE's capability for overlapping I/O and CPU activity. TPCOPY also conserves search time, taking advantage of the multi-file format of the off-line processing tapes. During tape search, for each file all that is necessary is a single READ to check the header record, followed by a single FORWARD SPACE FILE. This action repeats each file until the search terminates. The elimination of READs for every record represents a considerable saving in tape search time.

TPCOPY uses a single input unit and a single output unit with the tapes being mounted in sequence. Specified files may be selectively read from any number of input tapes and selectively written on any number of output tapes. Options are available to use output tapes with or without the volume serial label or BOI header label and to initialize tapes according to the user's specification.

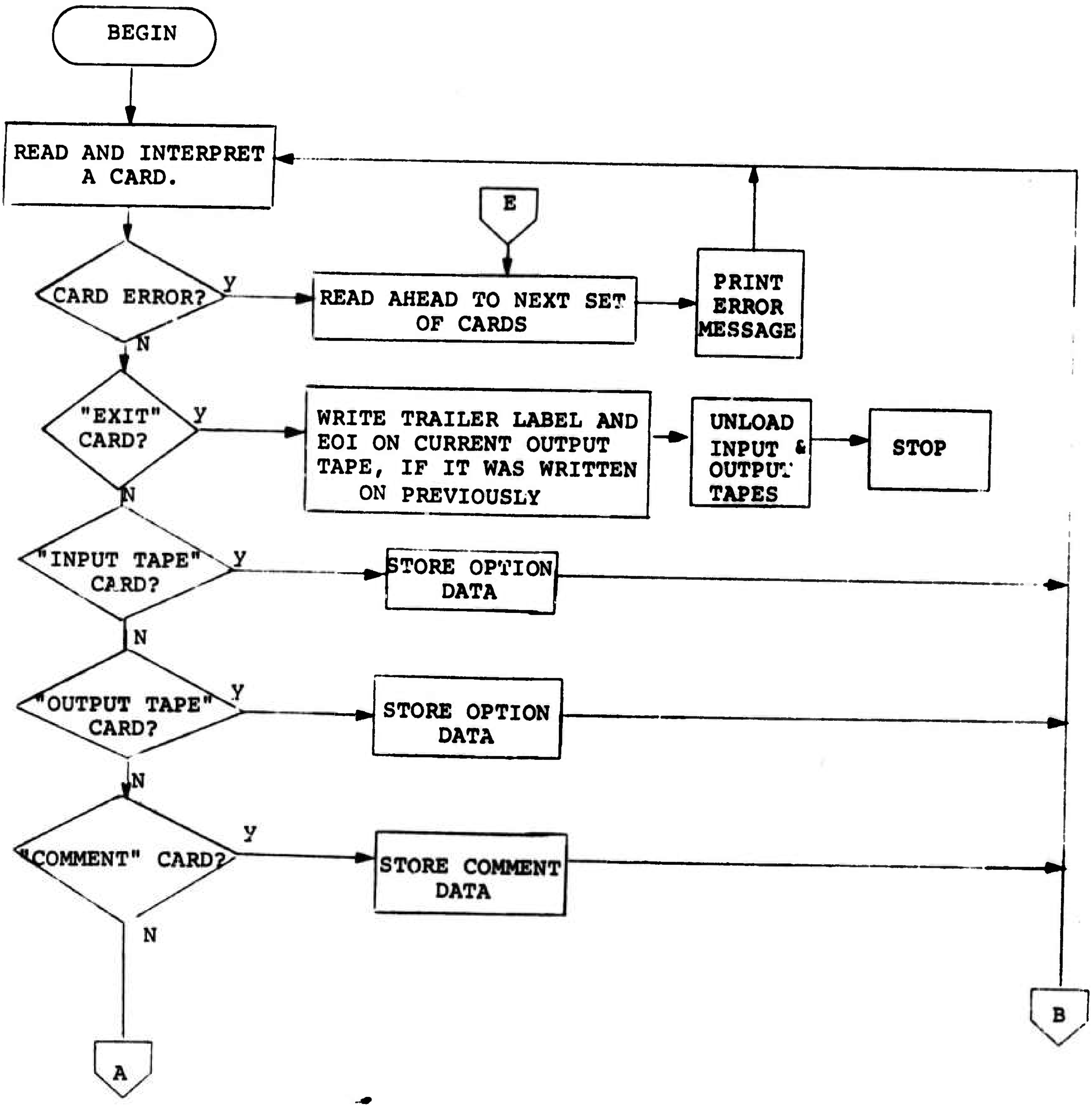


FIGURE III-18
TPCOPY GENERAL FLOW
PAGE 1 OF 3 PAGES

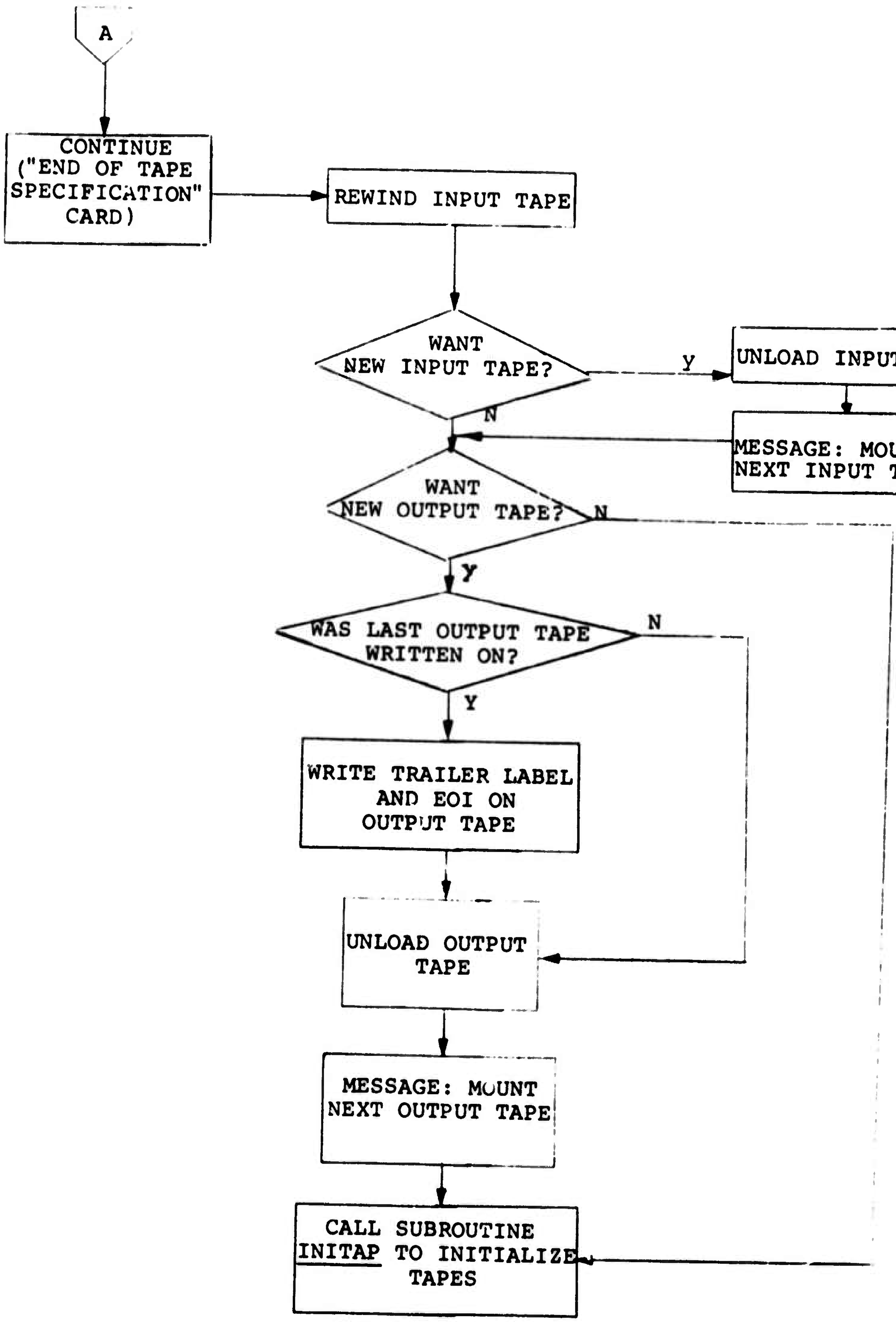


FIGURE III-18 (Cont'd)

PAGE 2 OF 3 PAGES

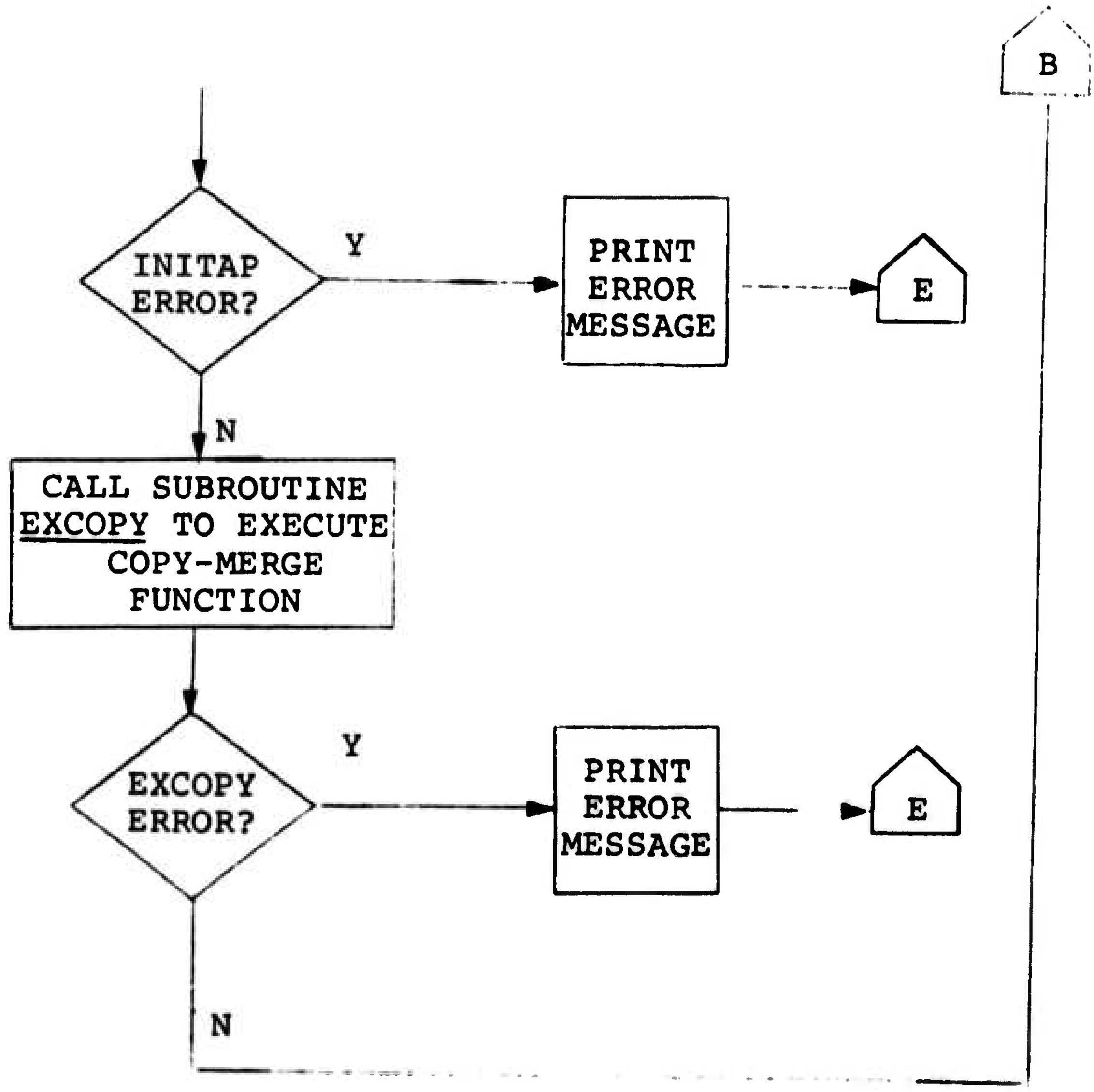


FIGURE III-18 (Cont'd)
TPCOPY
PAGE 3 OF 3 PAGES

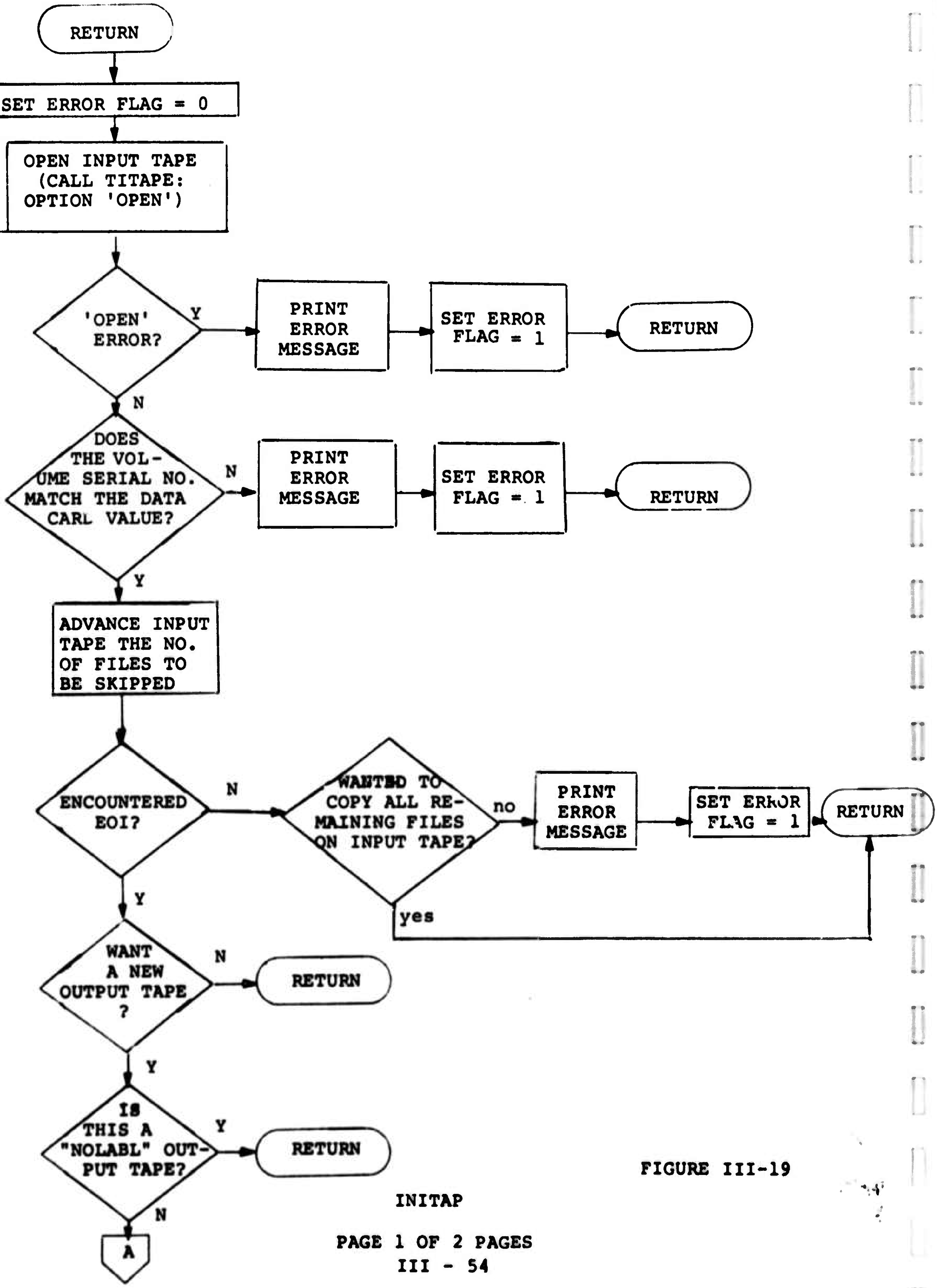


FIGURE III-19

INITAP

PAGE 1 OF 2 PAGES

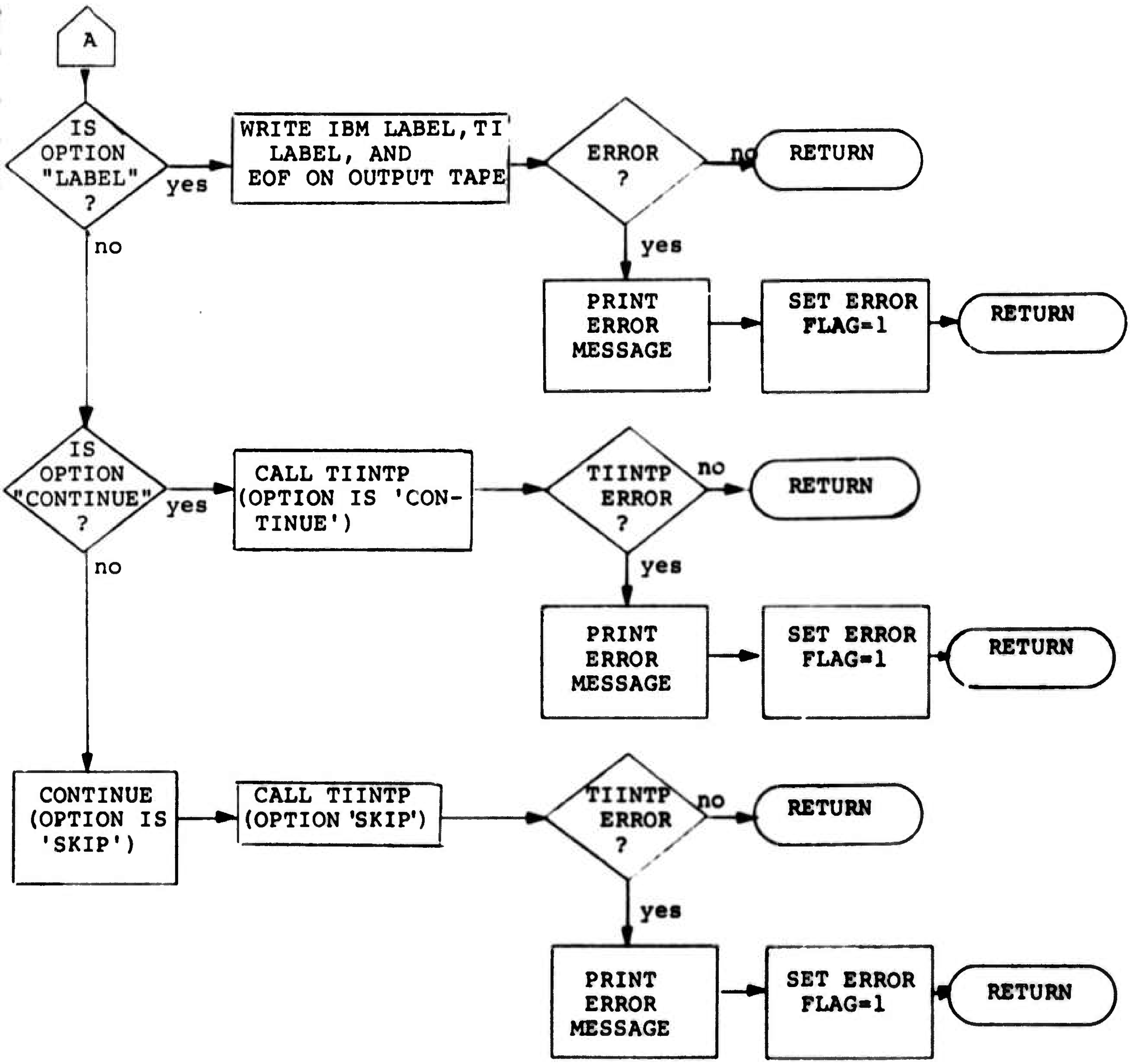


FIGURE III-19 (Cont'd)
INITAP

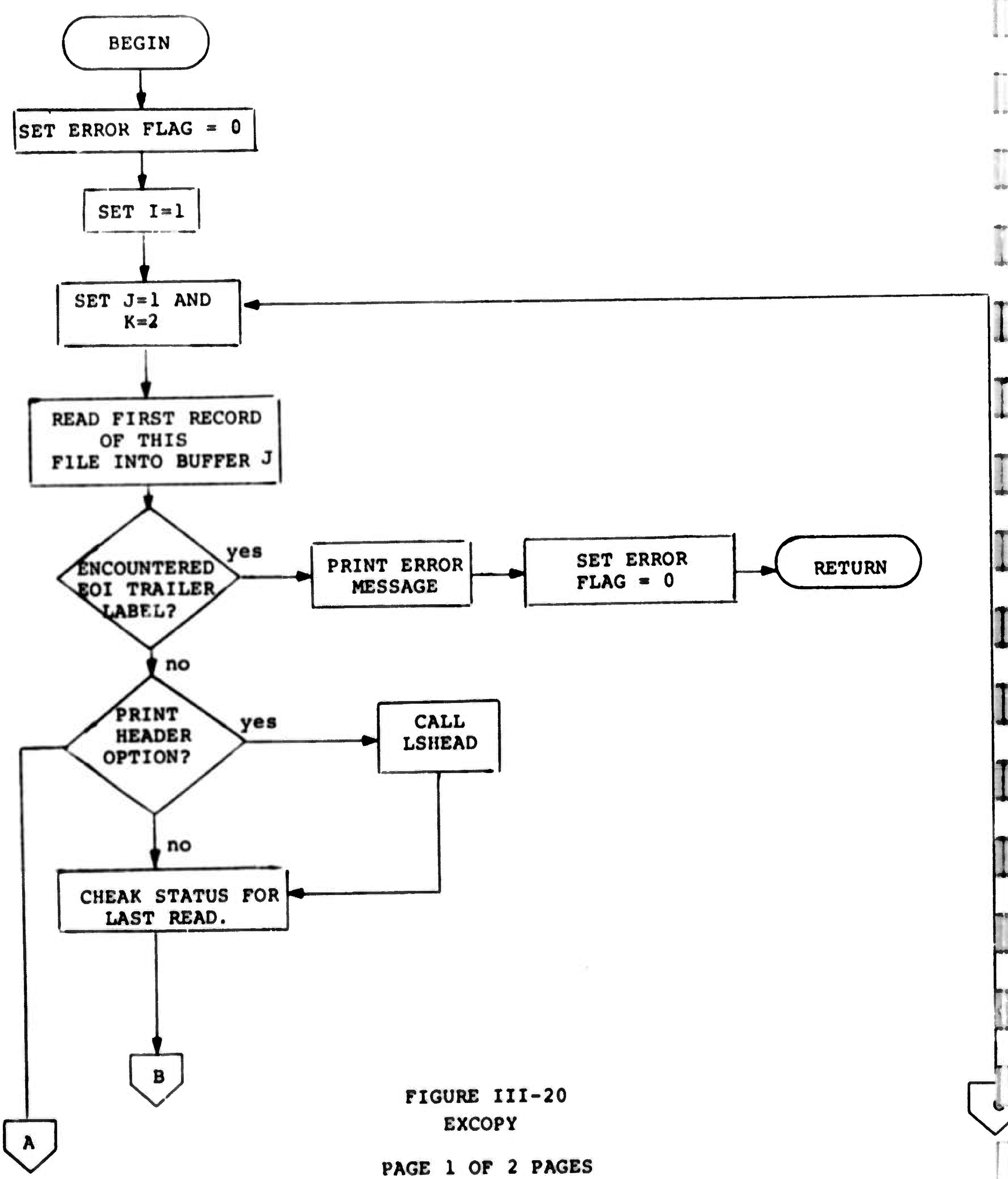


FIGURE III-20
EXCOPY

PAGE 1 OF 2 PAGES

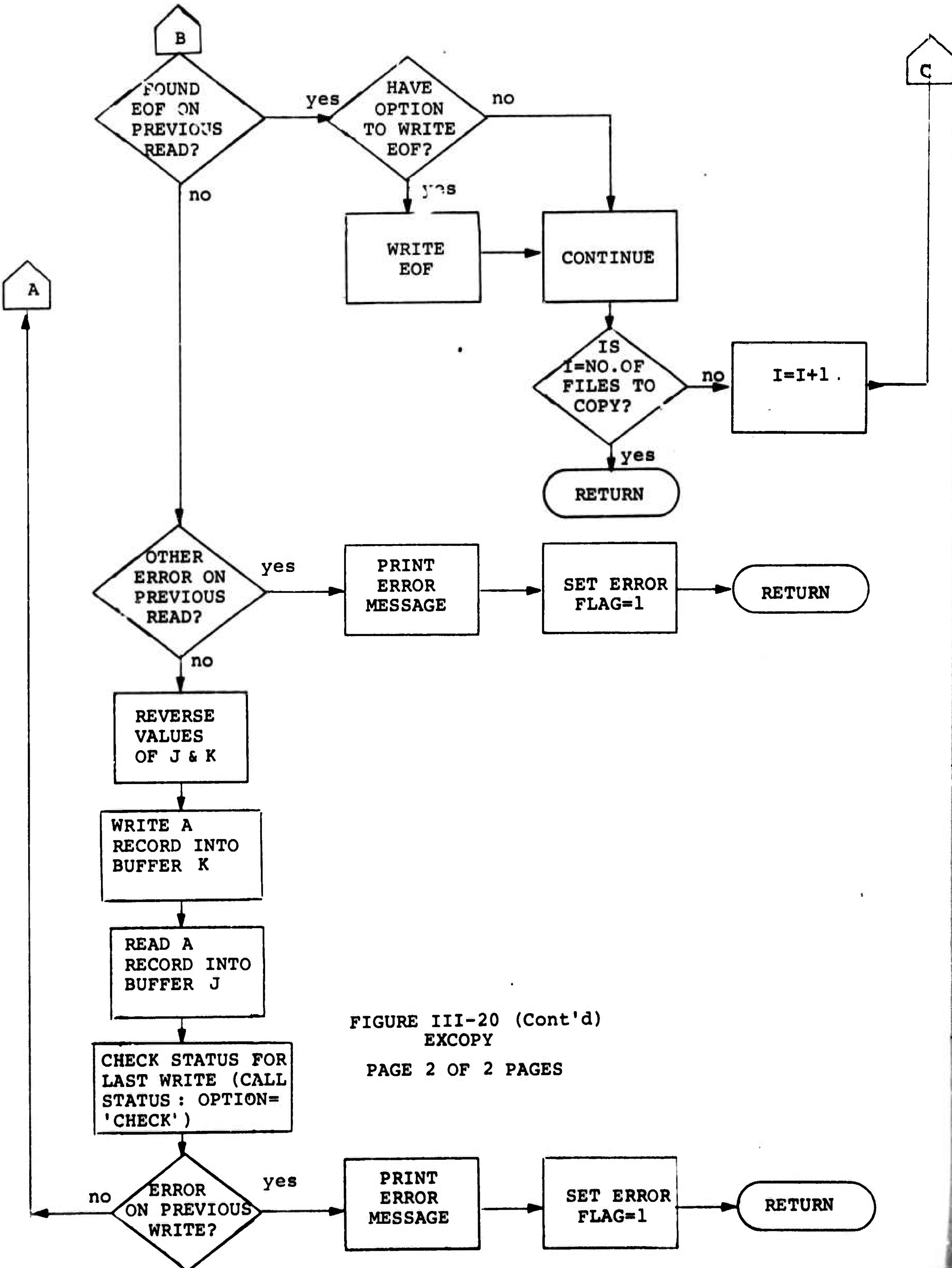


FIGURE III-20 (Cont'd)
EXCOPY

PAGE 2 OF 2 PAGES

5. Event Plot

The function of the EVPLOT program is to generate plot displays of time domain data, which is stored on TDDATA format tapes mulitplexed by (POINTS, COMPONENTS, SITES, SEGMENTS). The program extracts the required data, remultiplexes it to (POINTS, SEGMENTS, COMPONENTS, SITES), performs the appropriate blocking and scaling operations, and generates the plots. All tape input is performed through the support subroutines TITAPE and TIINTP; all output is accomplished through the IBM supplied plotting routines and the support module TIPLOT, which generate a plot tape to drive a Calcomp plotter. The plots are displayed on 30" paper; up to six sites (all three components) may be displayed on parallel axes. Program control is accomplished through data cards. Figure III-21 shows the general flow.

The EVPLOT main program opens the input tape and checks the volume serial number against that read from the first data card, and then opens and initializes the plot output tape. Serial mismatch or opening errors will cause the program to abort processing; otherwise control is passed to the primary subroutine PROCES (Figure III-22), which consists of a loop on events to be processed. Within each event, the data cards which specify the processing parameters are read and checked for errors: options include the plotting of any or all components across any or all sites, to a maximum of 22. Any number of segments may be displayed, beginning with any arbitrary segment. Horizontal and vertical scale factors may be specified, data can be rotated to the primary beam direction or to a specified azimuth, and means can be removed. The means and scale factors are either generated internally or read from cards generated by QCEDIT. A complete data dump to printer may be obtained if specified.

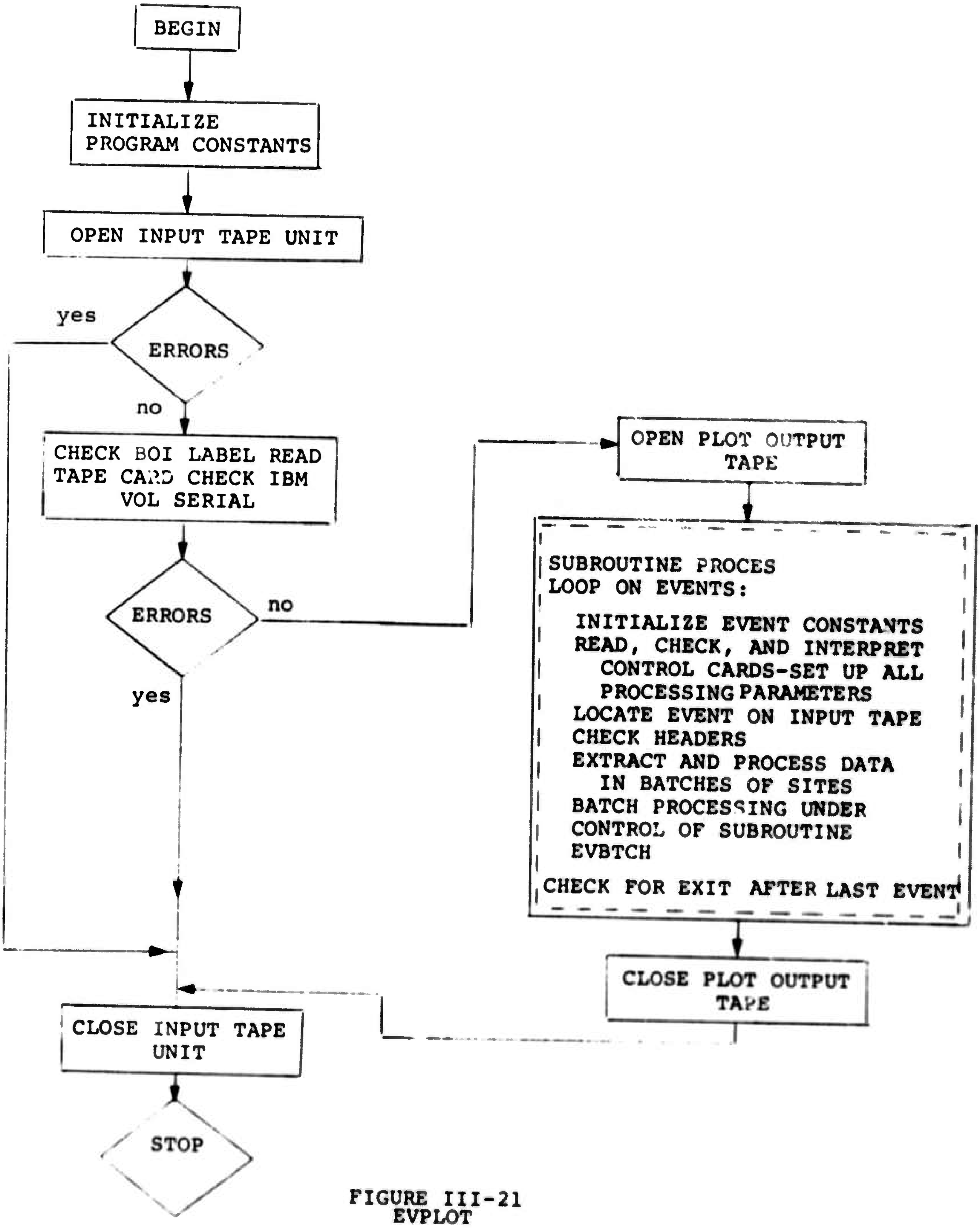


FIGURE III-21
EVPLOT
GENERAL FLOW

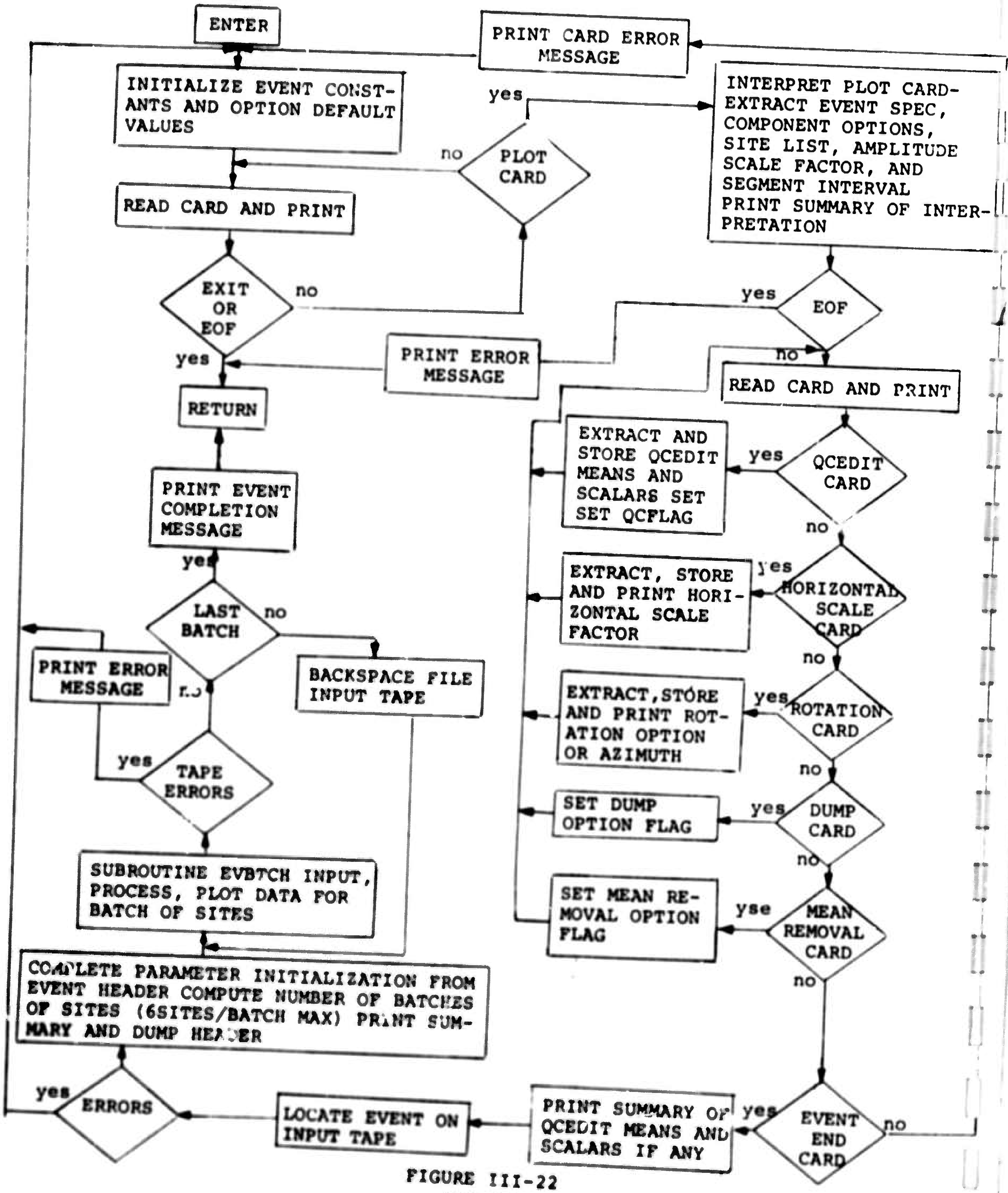


FIGURE III-22
PROCES

After reading the control cards for an event, the trace control parameters are set up to block the traces into displays six sites by five segments; control is then passed to subroutine EVBTCH (Figure III-23) which processes the successive batches of sites. Within this routine, the annotations and labels are generated, the required segments are input from tape, rotated or scaled as specified, remultiplexed, and plotted. Input, processing and plotting are overlapped for maximum efficiency; pen motion is minimized by combining axis and trace drawing into one pen traverse. End of file marks are written on the plot tape at the end of each batch of sites to provide plotter restart capability.

Printer output includes control card interpretation summaries and event header information. Any errors detected during processing of an event causes the program to skip to the next event. Program termination is by an exit data card or end of file at the card reader.

C. Package Checkout

To check out the ALPA off-line software, one large and one small earthquake were edited from the ALPA on-line data tapes. Also, an event from the TFO long period array was obtained from the Seismic Data Laboratory, Alexandria, Virginia, during the summer of 1969. This event was reformatted at SAAC to the ALPA on-line library tape format.

The three data samples were processed using the ALPA off-line package, and results were checked after each computer run to insure that the program performed correctly. Debugging and checkout of all off-line software was completed by 31 March 1970.

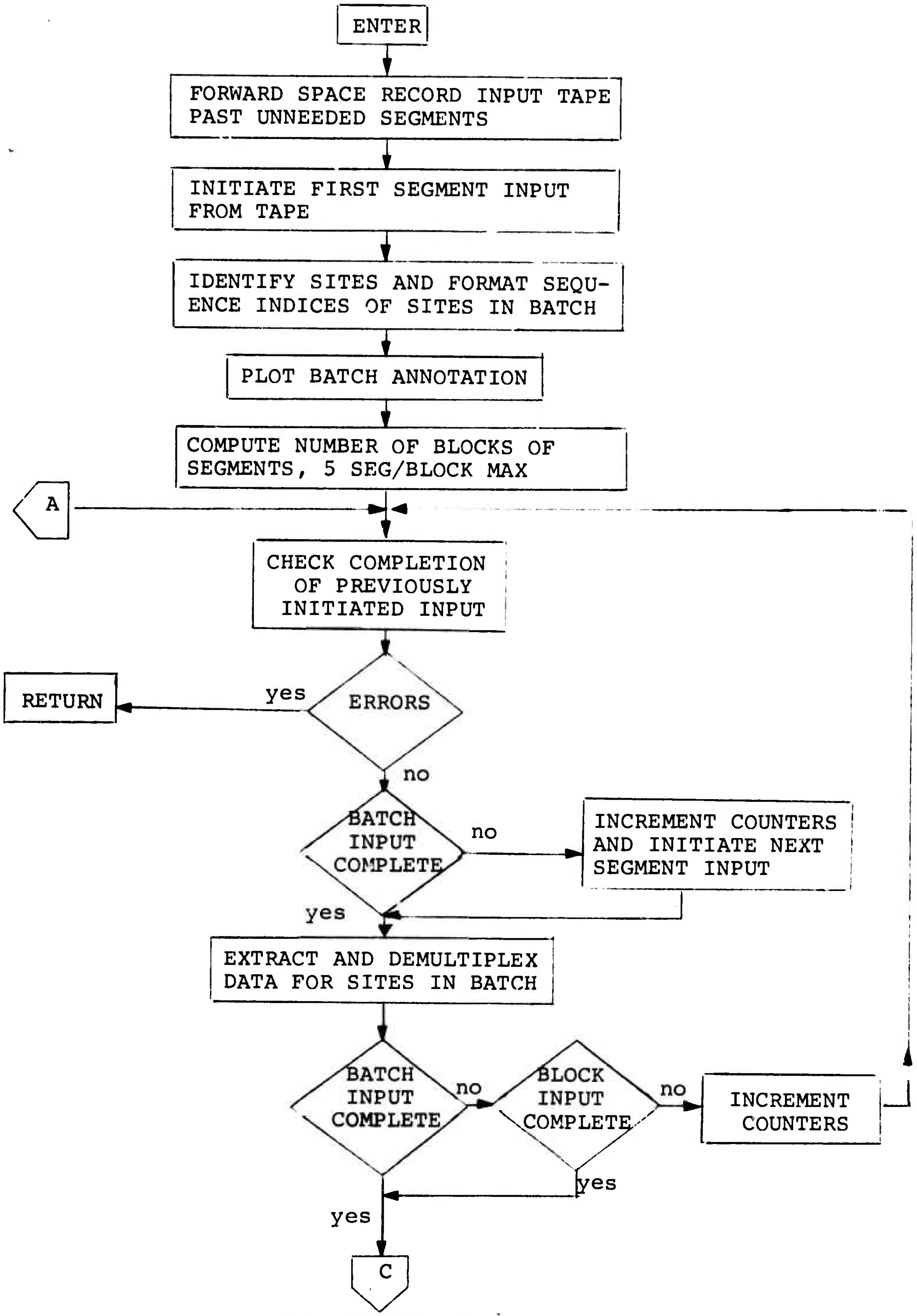


FIGURE III-23
EVBTCH

PAGE 1 OF 3 PAGES

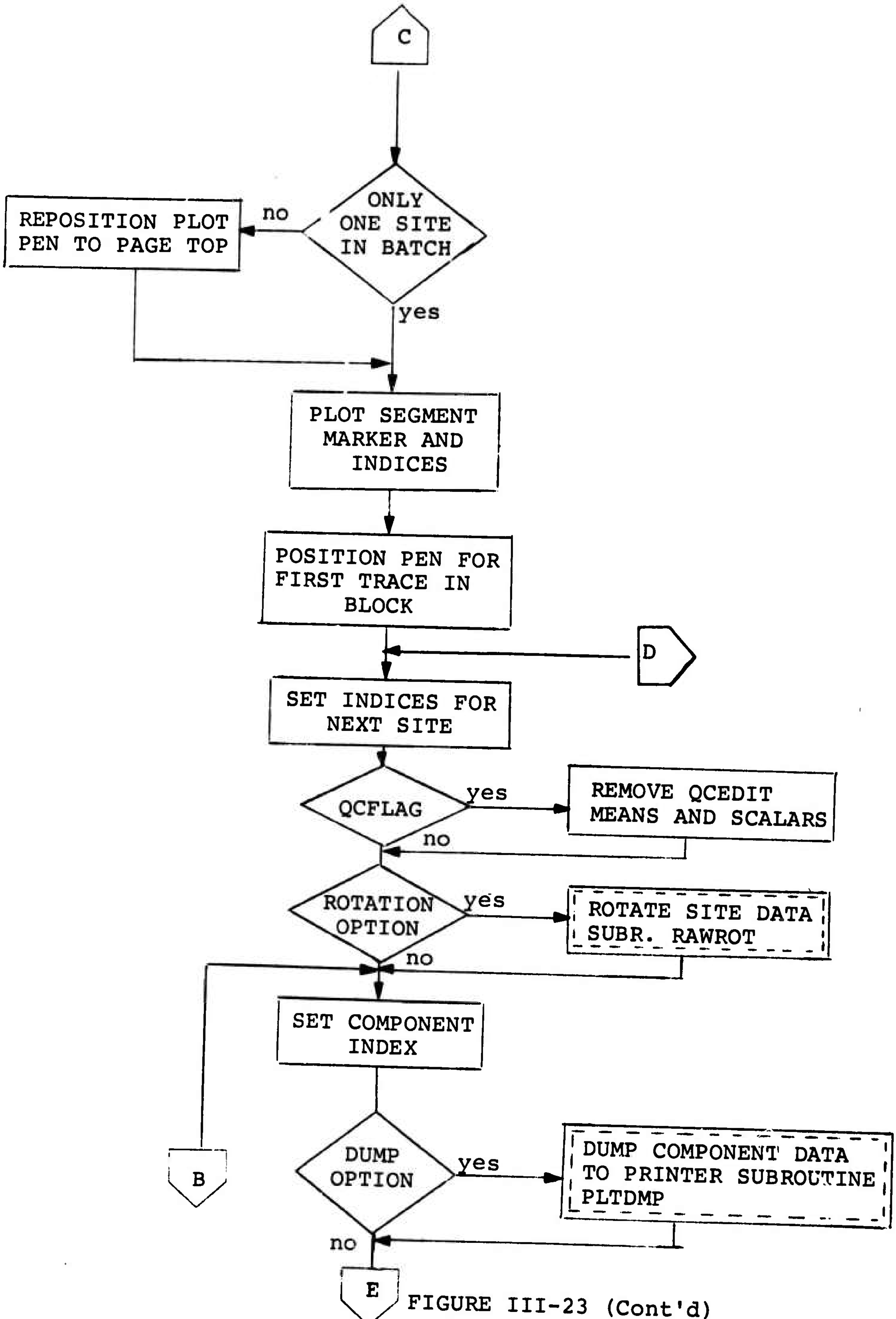


FIGURE III-23 (Cont'd)
EVBTCH

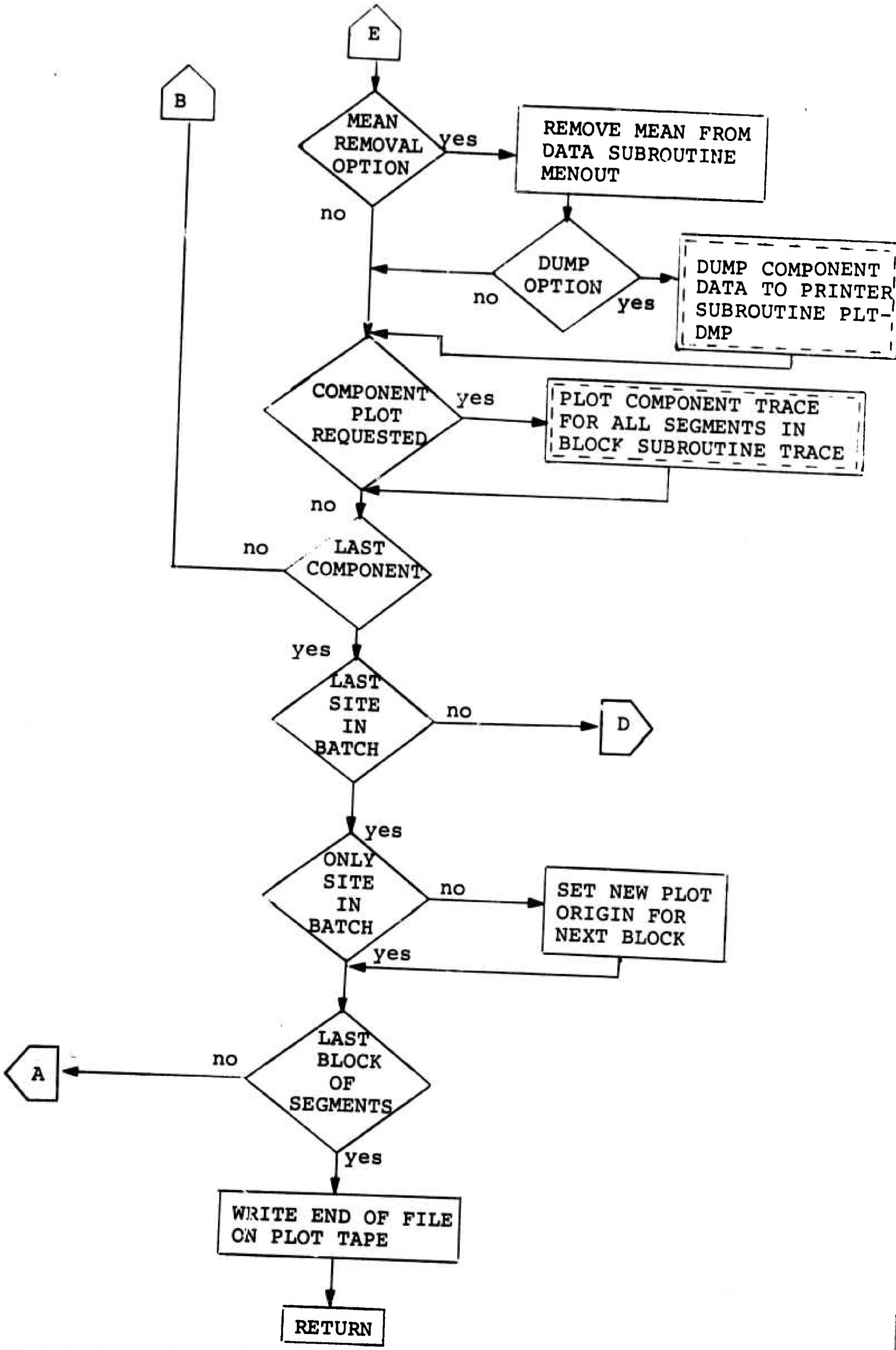


FIGURE III-23 (Cont'd) EVBTCH

PAGE 3 OF 3 PAGES

SECTION IV
ALPA EVALUATION

A. INTRODUCTION

To date ALPA evaluation has been limited for two reasons:

- The amount of data suitable for processing is quite small. The two main reasons are that very few sites have had all three seismometers operating at the same time, which precludes coordinate rotation, and much of the data (especially in April) have been unusable due to excessive spiking, which apparently is caused by problems in the radio data acquisition system at ALPA.

- Unexpectedly high long period noise (with periods greater than 20 seconds) was observed on most seismometers.

As a result, analysis has been limited to a study of this long period noise at a few sites, including development of a design technique to suppress it, and study of a few signals. Results are discussed in this section.

B. NOISE ANALYSIS

1. Spectral Studies

Noise samples distributed over the first 100 days of

1970 have been studied to determine some of the properties of the low frequency noise. Power spectra were obtained for both raw data and data rotated to a V, N, E orientation. The rotated data are of course easier to interpret physically and subsequent discussion will be confined to these samples. Site 3-3 was the only site which consistently had three operational seismometers so most of the discussion refers to this site.

The noise power spectra were estimated from 4096 second data samples. The spectra were smoothed before display by averaging over 17 adjacent frequencies.

All spectra had a peak at low frequencies, although both the frequency and the level varied. Table IV-1 lists the results for the 14 noise samples analysed. The frequency at which the peak occurred varied from .008 (125 seconds) to .021 (48 seconds), but no systematic change is evident. It is important to note that the phenomenon is, in general, relatively broadband. In fact, the low frequency peak overwhelms the 18-second microseismic peak on noisy days.

The peak power levels are plotted versus time in Figure IV-1. The mean daily temperature at ALPA also is shown in Figure IV-2 . Note that there is a discontinuity in the temperature curve at day 40; earlier readings were several degrees below zero, later readings were several degrees above zero. A definite change in the spectral levels appears to be associated with the temperature change; on days earlier than 40 levels were high and similar on the three components, on later days levels were lower and the vertical was significantly lower than the horizontals. In fact, on some later days the vertical power level is only a few db above system noise

These data suggest that two different mechanisms generate the observed long period noise. On "warm" days the data can be

DAY	TIME AT ALPA (HOURS:MIN)	FREQUENCY OF PEAK NOISE POWER	MAGNITUDE OF ROTATED POWER SPECTRUM (dB RELATIVE TO 1mμ2/Hz AT .04Hz)		
			VERTICAL	EAST	NORTH
5	14:47	.018	54.0	64.5	56.5
10	00:50	.021	55.5	64.5	57.0
20	11:13	.021	59.5	65.0	55.0
46	04:10	.021	47.0	63.5	50.5
59	22:01	.017	29.5	48.0	46.0
60	00:03	.021	42.5	54.5	51.0
66	06.50	.017	31.5	47.5	42.5
66	23:00	.008	36.0	57.5	52.5
73	08:30	.012	26.0	44.5	40.5
74	08:30	.008	27.0	46.5	41.5
75	05:00	.012	27.5	47.0	44.5
83	18:15	.012	24.5	41.0	37.0
84	05:26	.012	26.0	45.5	43.0
92	03:37	.017	34.5	52.5	50.5

Table IV-1. Peak Power Values at Low Frequency For Site 3-3

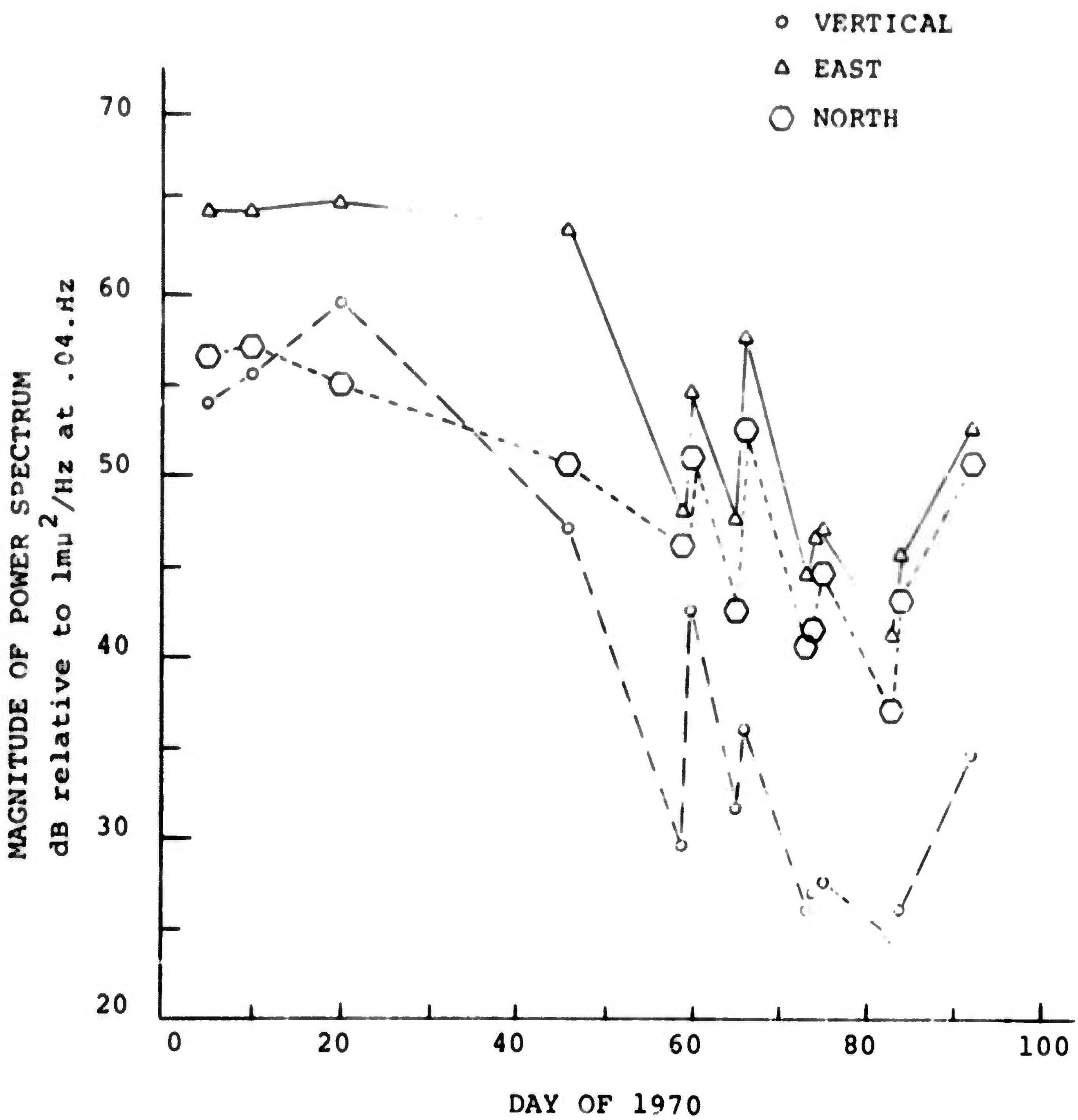


Figure IV-1. Peak Power Vales at Low Frequency for Site 3-3

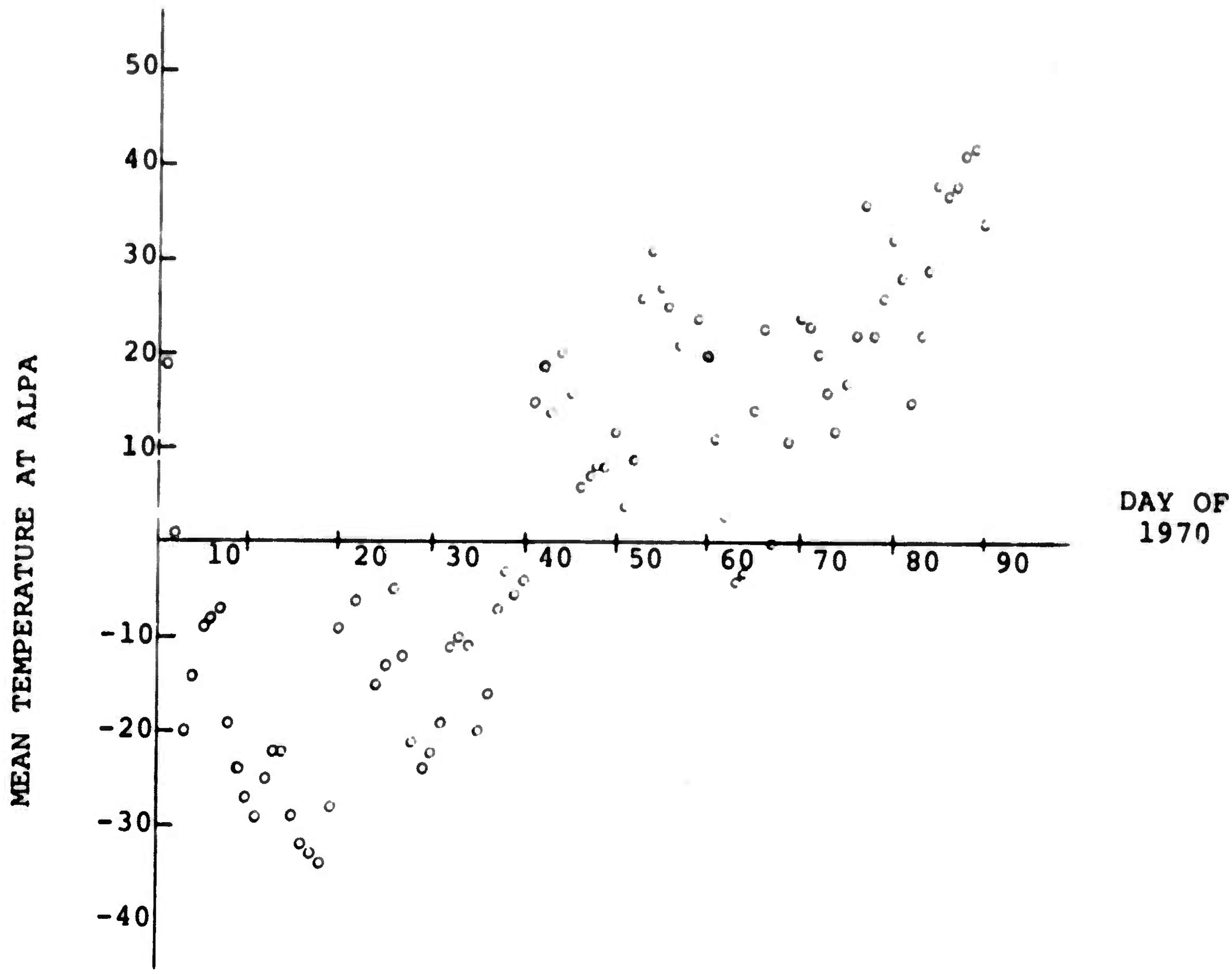


FIGURE IV-2

MEAN DAILY TEMPERATURE AT ALPA

explained by ground tilt due to variations in atmospheric loading; this phenomenon has been observed at LASA. On very cold days an additional generating mechanism becomes active (ground tilt no doubt still occurs). Results of field tests indicate that temperature is not the direct cause, however it seems clear that the mechanism is temperature dependent. We do not know of a physical explanation for this phenomenon.

To further examine the noise characteristics two-channel coherences were computed both between components at a given site and between like components of two different sites. The same noise data were used in this study.

The peak coherences in the low frequency range between components at Site 3-3 are listed in Table IV-2. It can be seen that when low frequency noise is high (e.g., day 20) the three trace pairs show very high coherence. On later days the coherences involving the vertical drop significantly, but the NS-EW values remain high.

Examination of the phase angles of the crosspower spectra show that on days prior to 40 the traces are either in or out of phase for all three components. On days later than 40 the horizontals continue to be either in or out of phase but the vertical-horizontal phase relationship is more complicated. In addition, the phase relationship between two given components (except the later vericals) remains the same as a function of time (i.e., they are always either in or out of phase), and the phase relationships are not necessarly the same for two like components at different sites. The intra-site coherence and phase data appear consistent with the interpretation given above from analysis of the power spectra.

DAY	TIME AT ALPA (HOURS:MIN)	FREQUENCY OF PEAK NOISE POWER	MAGNITUDE OF ROTATED POWER SPECTRUM (dB RELATIVE TO $1 m\mu^2/Hz$ AT .04Hz)			COHERENCES		
			VERTICAL	EAST	NORTH	VERTICAL & EAST	VERTICAL & NORTH	NORTH & EAST
20	11:13	.021	59.5	65.0	55.0	.92	.90	.90
59	22:01	.017	29.5	48.0	46.0	.72	.74	.97
60	00:03	.021	42.5	54.5	51.0	.65	.57	.85
73	08:30	.012	26.0	44.5	40.5	.68	.63	.91
74	08:30	.008	27.0	46.0	41.5	.50	.42	.83
75	05:00	.012	28.5	47.0	44.5	.70	.68	.98
83	18:15	.012	24.5	41.0	37.0	.40	.44	.94
84	05:26	.012	26.0	45.5	43.0	.66	.57	.88

TABLE 2. Peak Coherences Between Components at Site 3-3

The coherences between like components at different sites are essentially zero for the low frequency noise. Note that the inter-site coherences for the vertical channels on quiet days show significant levels at the 18-second microseismic peak, which would be expected for the site spacings at ALPA.

The low coherence between sites and the phase relationships between components at a given site indicate that the low frequency noise either is non-propagating or is atmospherically coupled and propagating at a very low velocity. In any case the energy certainly is not Rayleigh wave in nature.

In summary, on very cold days the long period noise has the following properties:

- Very high level
- Relatively broadband (often dominates the 18-second seismic peak)
- Incoherent between sites
- Highly coherent between components at a given site
- Either in or out of phase
- The phase between components at a given site remains constant over long time periods, but may be different for the same two components at a different site.

No specific physical explanation is known for this phenomenon but it is certainly not propagating Rayleigh wave energy.

On "warm days" the long-period noise can be explained by ground tilt due to atmospheric loading.

Note that the above interpretation has been made primarily from Site 3-3 data; it may have to be modified when additional data are available for analysis.

2. Two Component Rayleigh Wave Signal Extraction

The long-period noise described in the previous subsection obviously presents a serious problem in data analysis, especially on days where high levels are observed on the vertical channel. A processing technique to suppress this noise would be desirable.

Recall that the noise was highly coherent between two sensors at a given site and that the sensors were either in or out of phase. This relationship holds whether the triax seismometers are rotated to V, N, E orientation or to an orientation Vertical, Transverse and Radial to the propagation vector of a signal to be processed.

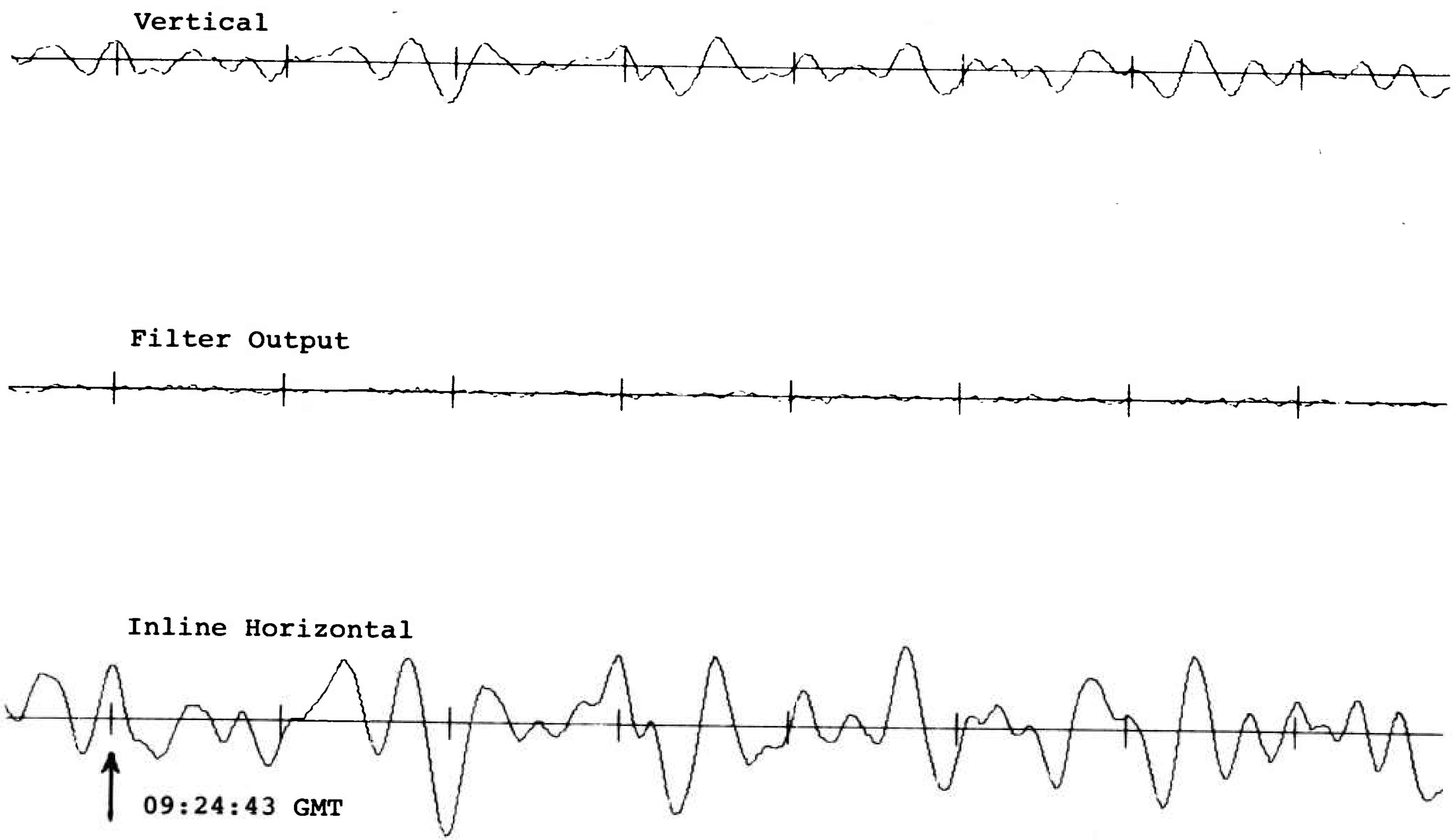
The coherence between a vertical and radial sensor for a fundamental Rayleigh wave signal also is very high, but in this case the phase relationship is 90°. This difference in the phase angles for the long-period noise and a Rayleigh-wave signal suggests that a simple two channel signal extraction filter could be designed to suppress the long period noise without distorting the Rayleigh wave.

To investigate this possibility a two-channel Weiner multichannel filter (MCF) has been designed to extract the

vertical component of a Rayleigh-wave signal. The signal crosspower spectra required in the design were obtained from a theoretical model. It was assumed that the radial signal component leads the vertical by 90° and has an amplitude spectrum equal to 0.8 times that of the vertical. The noise crosspowers were estimated from 2048 seconds of recorded data. The data was resampled to a two-second sampling interval and transformed in segments of 64 points each. After forming crosspower spectral matrices within each segment the matrices were averaged across segments. At each frequency the vertical component signal power density was assumed to be four times the average of the vertical and radial component noise power densities. The filters were designed in the frequency domain and inverse Fourier transformed to yield 64 point filters.

This procedure was followed for a 10 January, 1970 Philippine Sea event (origin time 12.07.09 GMT; lat. 6.8N; long. 126.7E; m_b=6.1). The segment used for estimating the noise crosspower spectra preceded the Rayleigh-wave onset by about three hours. Individual filter sets were designed for each of Sites 3-23, 3-3, and 3-34. The filters then were applied to the noise from which they were designed (Figure IV-3). As a measure of performance we use the noise power density integrated over the range 0.025 to 0.05hz; the three MCF's suppressed the vertical component noise power by 10 to 20 db. The output power spectra for the three MCF's in this frequency range varied from 26 to 33db relative to 1mμ^2/Hz at .04 H_z. This level is similar to normal vertical component ambient noise at LASA.

The same MCF's were applied to a noise segment recorded 1.5 hours after the design noise (Figure IV-4). Output noise levels increased by one or two db.



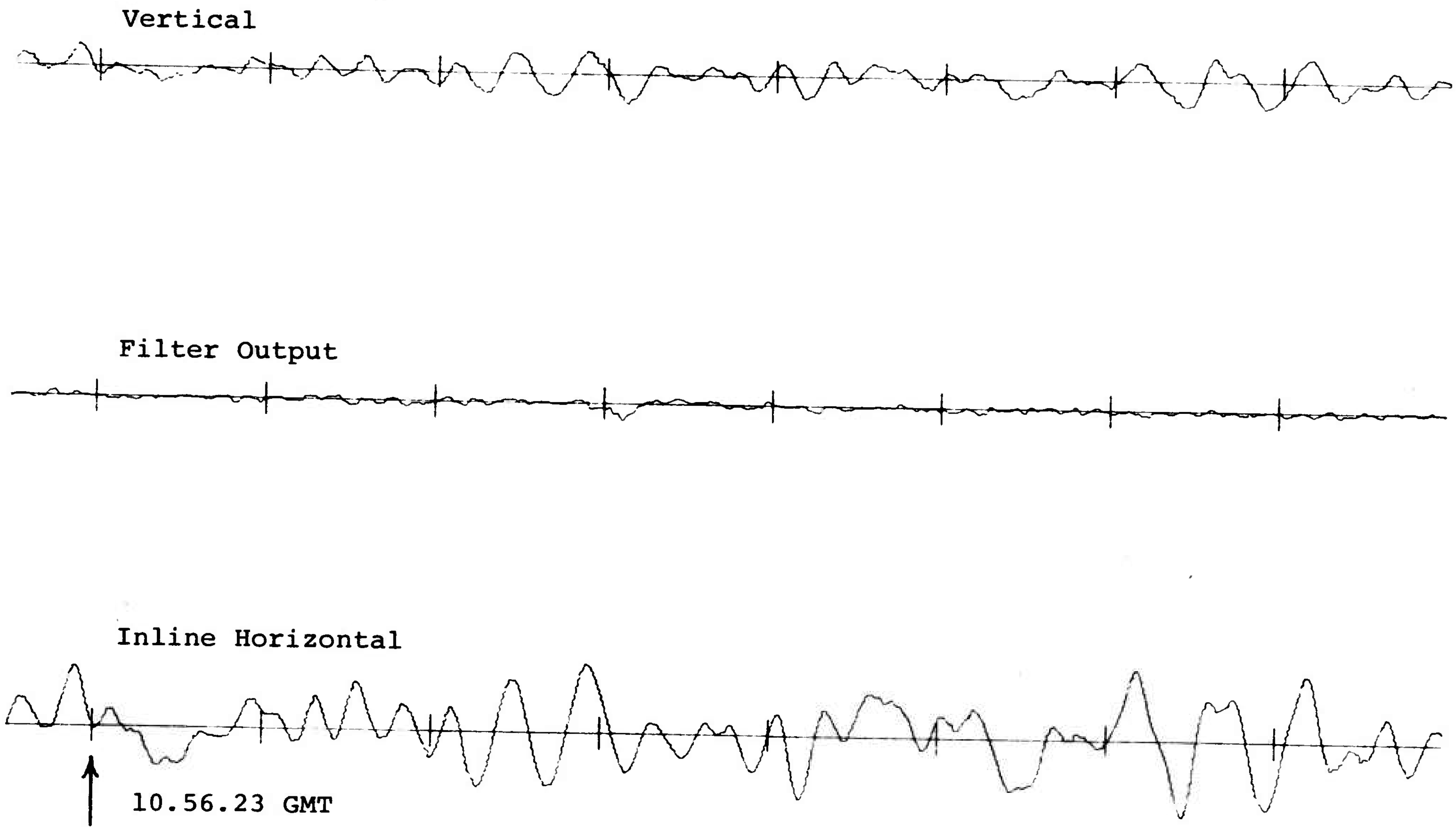
Site 3-3

FIGURE IV-3

100 seconds/inch

1.13 microns/inch at 0.04 hertz

Two-Component Rayleigh Wave Signal-Extraction Filter Applied to "Design" Noise



Site 3-3

100 seconds/inch

1.13 microns/inch at 0.04 hertz

FIGURE IV-4

Two-Component Rayleigh Wave Signal-Extraction Filter Applied to "Off-Design" Noise

When the MCF's were applied to the signal, the signal degradation seen on both wiggly traces and power density spectra was found to be quite small (Figure IV-5).

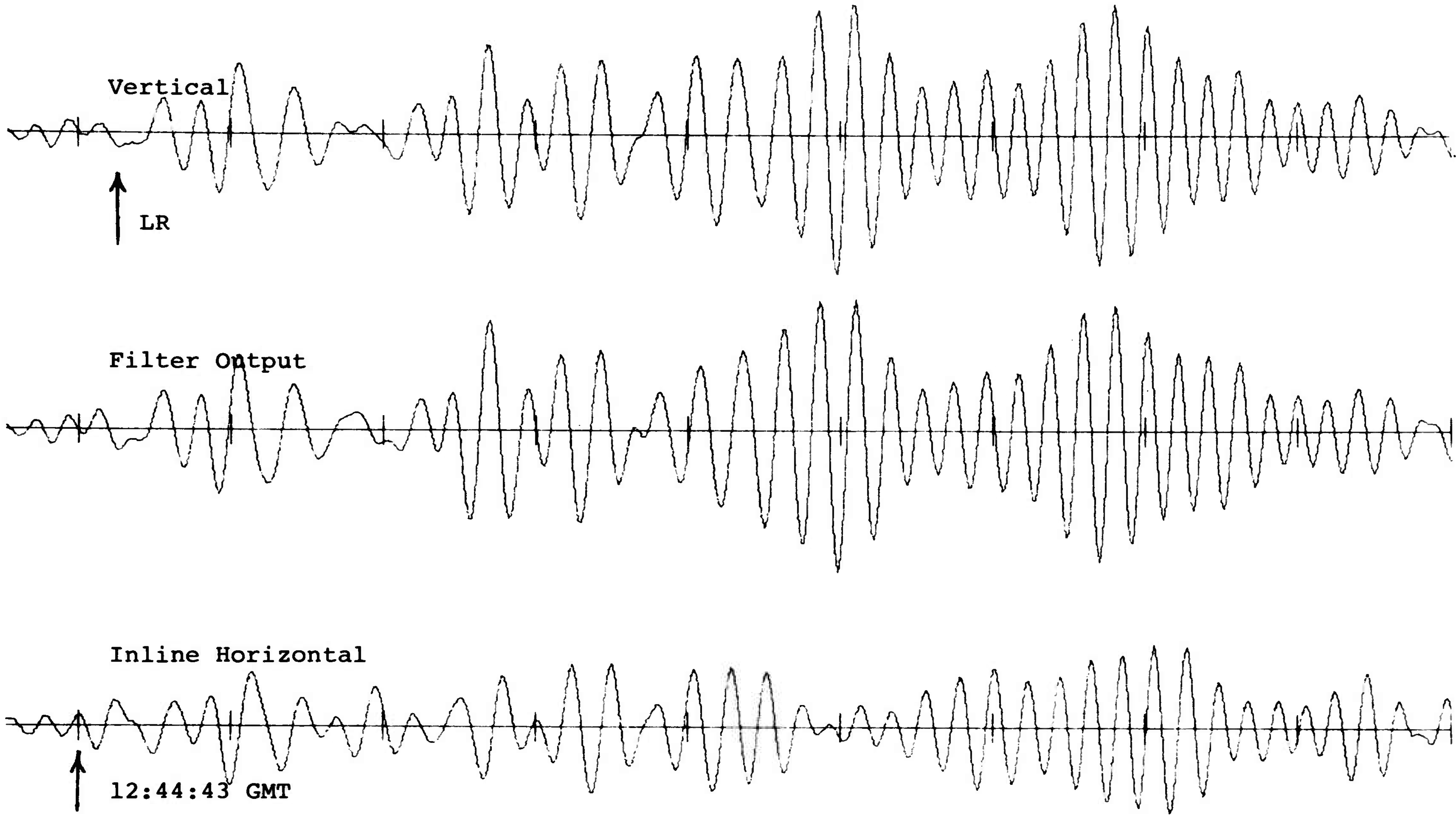
The experiment was repeated on March 16 data - when the long-period noise level appeared to be relatively low. The event used in this case occurred in the Fiji Islands (origin time 06.44.17; lat. 17.05; long. 176.5 W; m_b=4.9). On this date only Sites 3-3 and 3-23 could be rotated. Power spectra of the vertical component long-period noise were very low at both sites and the MCF's achieved no greater than eight db suppression. Once again signal perservation was excellent.

These results indicate that when anomalously high long period noise exists on the vertical it can be effectively suppressed. Note that the technique can be used only to extract a vertical-component Rayleigh wave; no analagous technique exists for Love and body wave extraction. Also additional programming effort would be required to implement this technique in the off-line software (the study was performed using a special program).

C. SIGNAL ANALYSIS

To date signal analysis has been limited, primarily because very few sites are available with three operational seismometers. However, Calcomp plots, power density spectra and coherences have been generated for a few events (using rotated data).

Figure IV-6 shown rotated time traces recorded at



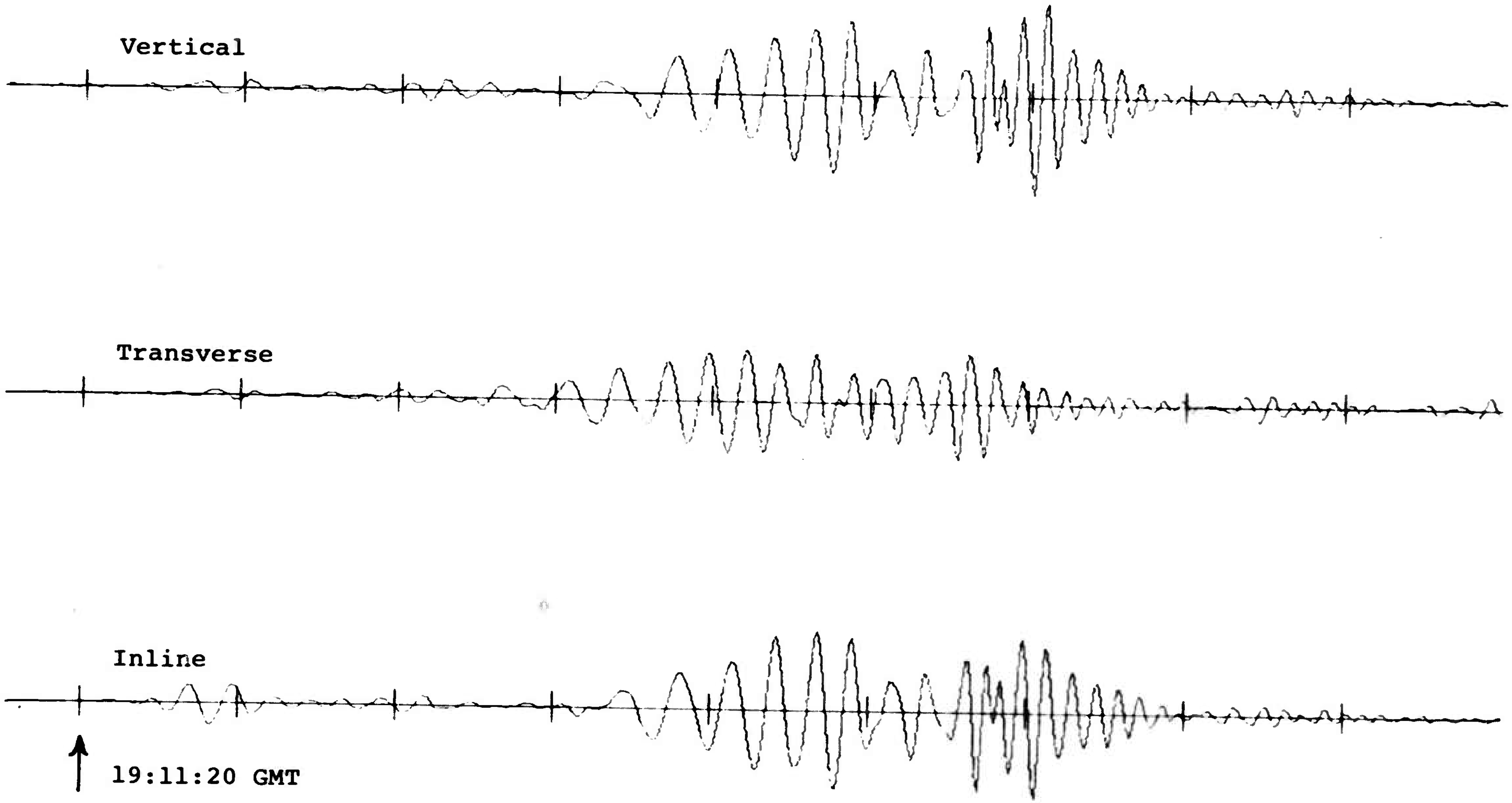
Site 3-3

100 seconds/inch

113.0 microns/inch at 0.04 hertz

FIGURE IV-5

Two-Component Rayleigh Wave Signal-Extraction Filter Applied to 1/10/70 Event



100 seconds/inch

FIGURE IV-6

11.3 microns/inch at 0.04 hertz

"HANDLEY" Recorded at Site 3-3, Alaskan Long Period Array

Site 3-3 for an event from NTS (origin time=19:00:00 GMT, March 26, 1970; Δ=33°; azimuth=133°). There is a clear S wave at about 19:12:00 and a possible SS wave at about 19:14:00 followed by the surface waves. A clear interference pattern is evident about three minutes into the Rayleigh wave. This shows up in the power density spectra as a notch at about twenty seconds. The presence of multipath interference is not surprising since the great circle path for this event passes directly over the Pacific coastline of British Columbia. Note that the interference pattern is similar for the Love and Rayleigh waves.

The power density spectra peaked at 0.042 hz for the Rayleigh wave and 0.045 hz for the Love wave. The relatively short epicentral distance results in fairly wideband spectra. The ALPA M_s for this event is 5.1.

A complicated surface wave train also was observed for an event originating in the Philipine Islands area. In this case the great circle path traverses Japan and the Kamchatka Peninsula, so severe interference would be expected. Conversely, an event from the Fiji islands with a primarily oceanic path had simple surface waves.

Note that ALPA's location is such that surface waves from most earthquakes in the circum-Pacific belt should be complicated because of the irregular travel path. This suggests that matched filtering may be highly sensitive to the event location for ALPA data.

D. FUTURE PLANS

As mentioned previously, off-line evaluation is

limited at present by data availability. We will continue to monitor the data and perform limited analysis such as that described in this section. When sufficient data are available routine off-line processing will be initiated. Note that the nine sites currently being transmitted to SAAC would provide an adequate data base for evaluation if the current dead channel and spiking problems were overcome.

BLANK PAGE

SECTION V
LONG PERIOD EXPERIMENT

A. INTRODUCTION

During the past quarter, the basic design of the Long Period Experiment (LPE) was completed. Routine processing in this experiment consists of obtaining a best waveform from each of the long period stations and analyzing these waveforms to determine the detection capability of each of the stations and the detection and discrimination capability of the network.

In general the processing will perform four main functions - library tape generation, quality check and edit, single station processing and analysis, and network processing and analysis.

B. PACKAGE DESIGN

The basic principle in the design of the processing packages is to utilize the ALPA long period off-line software whenever possible. Therefore, program flow for LPE follows the general flow of the ALPA off-line package when computationally possible. To distinguish LPE software from ALPA software, all LPE program names and data formats will begin with the letters "LX".

The general flow of the software is shown in Figure V-1. Routine processing consists of the main line programs LXMERG,

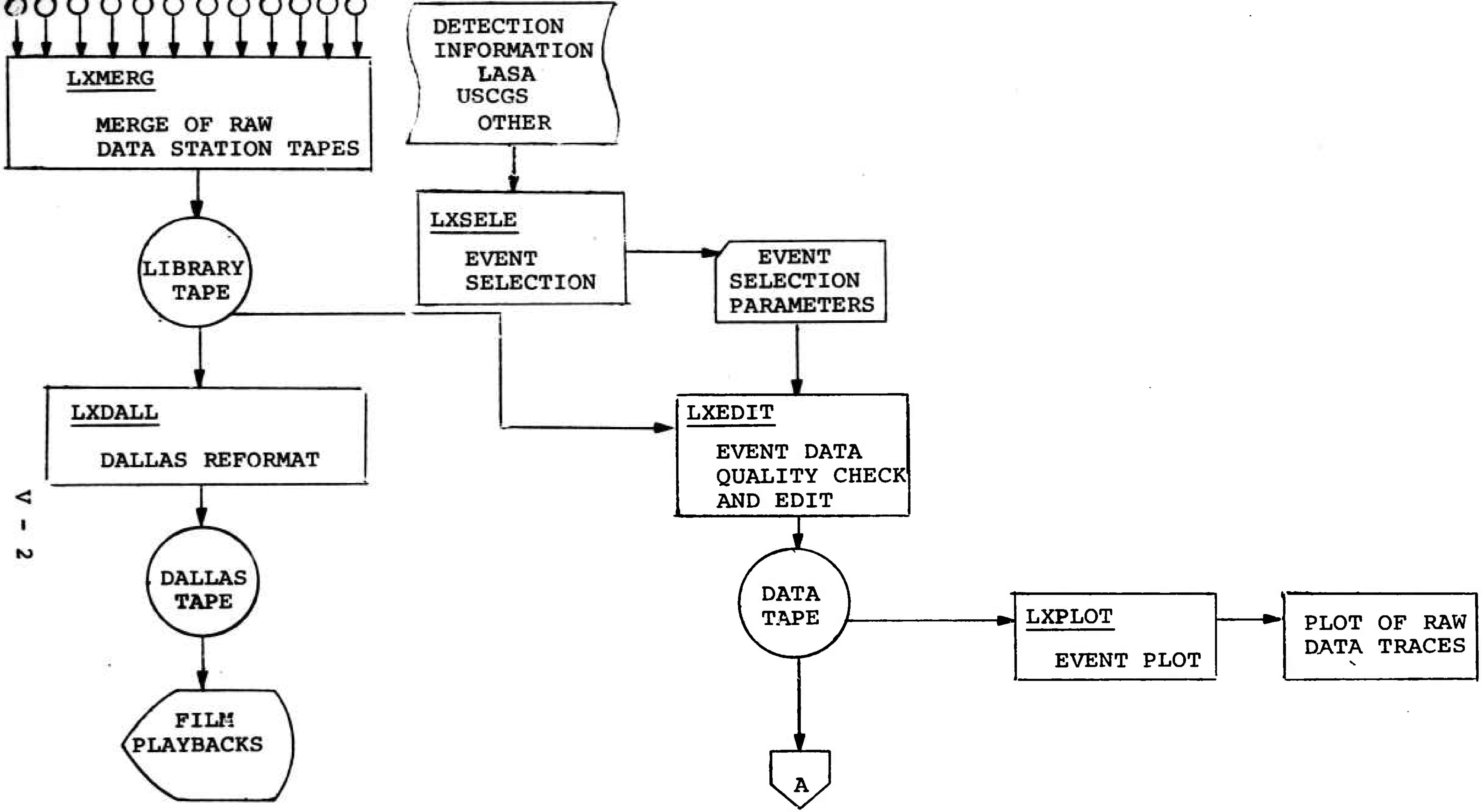
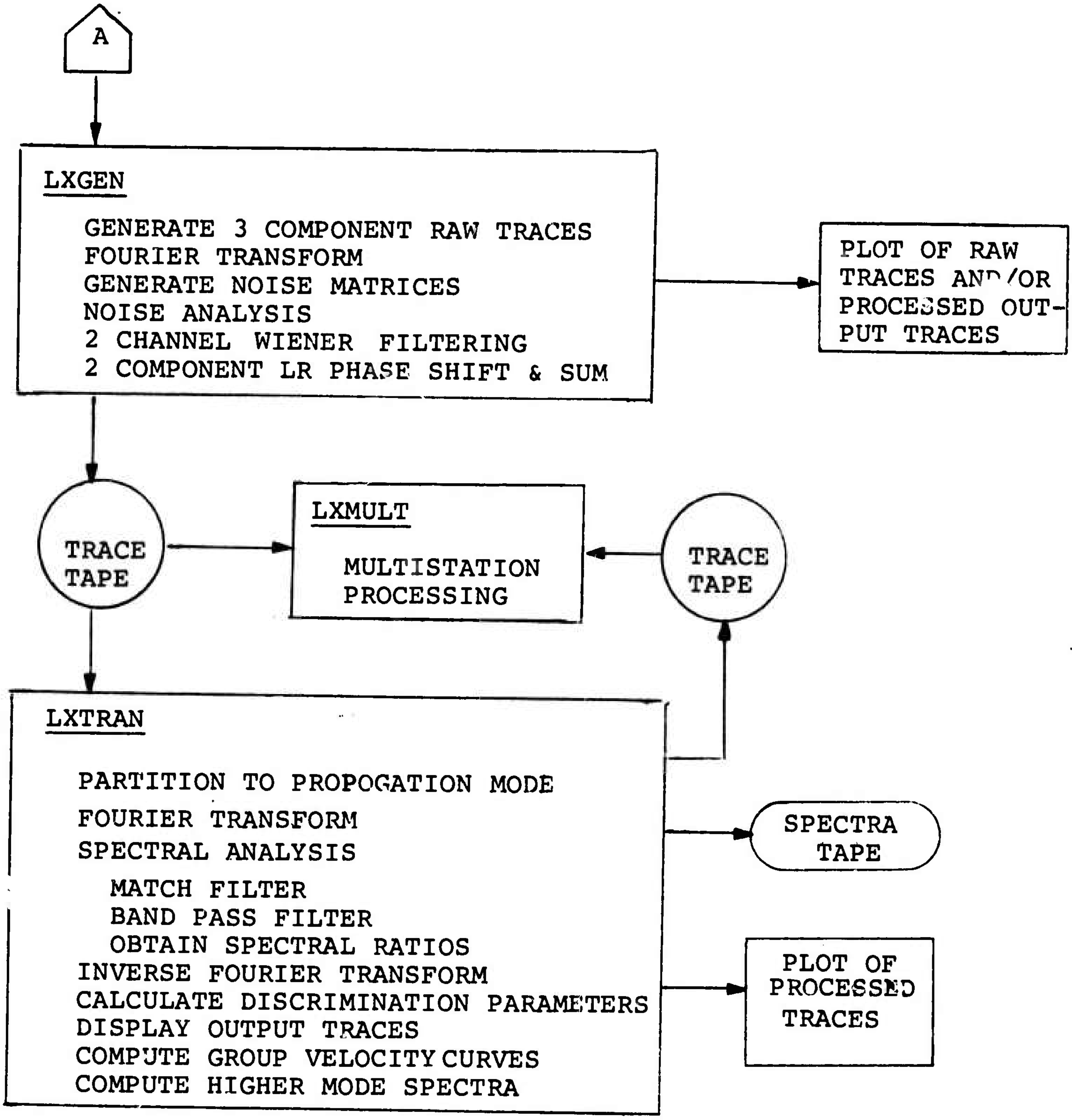


FIGURE V-1
LONG PERIOD EXPERIMENT
DATA FLOW AND MAIN
PROGRAM FUNCTIONS

PAGE 1 OF 2 PAGES



LONG PERIOD EXPERIMENT
DATA FLOW AND MAIN
PROGRAM FUNCTIONS

PAGE 2 OF 2 PAGES

LXEDIT, LXGEN, and LXTRAN, and support programs LXSELE, LXDALL, LXPLOT, and LXMULT. The data flow is organized so that a large number of events may be "batch" processed. The following subsections present a brief description of each of the programs. Also, flow charts are included for three of the major packages.

1. LXMERG

Program LXMERG reads the station tapes and generates time multiplexed SAAC library tapes. During the merge data will be reformatted from 7 track 556 bpi to 9 track 1600 bpi. These high-density tapes will be retained at SAAC and will form the permanent library of the LPE data. In addition to collecting and merging the data, this program also will perform data resampling if desired. To facilitate the use of the library tapes by other interested parties, station headers will be retained.

2. LXDALL

This program generates a tape which will be used as input to the playback center in Dallas, where 16 mm films of the data will be made. LXDALL formats the time-mulitplexed library tape described above to 7 track 556 bpi format. An attempt will be made to make this low density copy of the library tape compatable with computer systems of other users.

3. LXSELE

This program uses the PDE information for events to

be processed to generate event parameters for each station, and to calculate event edit parameters. The program is designed to show the analyst what data will be edited in LXEDIT before he performs the actual data edit. It should be noted that the analyst can specify edit parameters in both LXSELE and LXEDIT. LXSELE is analogous to the ALPA off-line program SELECT.

4. LXEDIT

LXEDIT edits and quality checks data from the library tapes. Its general flow is shown in Figure V-2, and is analogous to the ALPA off-line program QCEDIT. The first function is to setup a permanent header array for all events to be processed. This includes the station code names and locations as well as various flag words. Then, after initializing the input and output processing tapes, a PDE data card is read. From this card the following parameters are calculated for each station: P, S, LQ, and LR arrival times, maximum duration of the LR wave train, and the great circle distance and azimuth from the station to the event. From the phase arrival times an event edit time and length is calculated. The length will include all phases and a sufficient amount of noise for each station to allow for future noise analysis. It should be noted that the edited data will be time aligned for all stations.

The library tape then is searched for the desired edit time. After locating the desired edit time, the data are processed in segments of 128 data points for each station-component. In processing the segments, the data may be resampled if desired and quality checks are performed. In the quality ckecks, spikes and/or clips are corrected, and all errors are

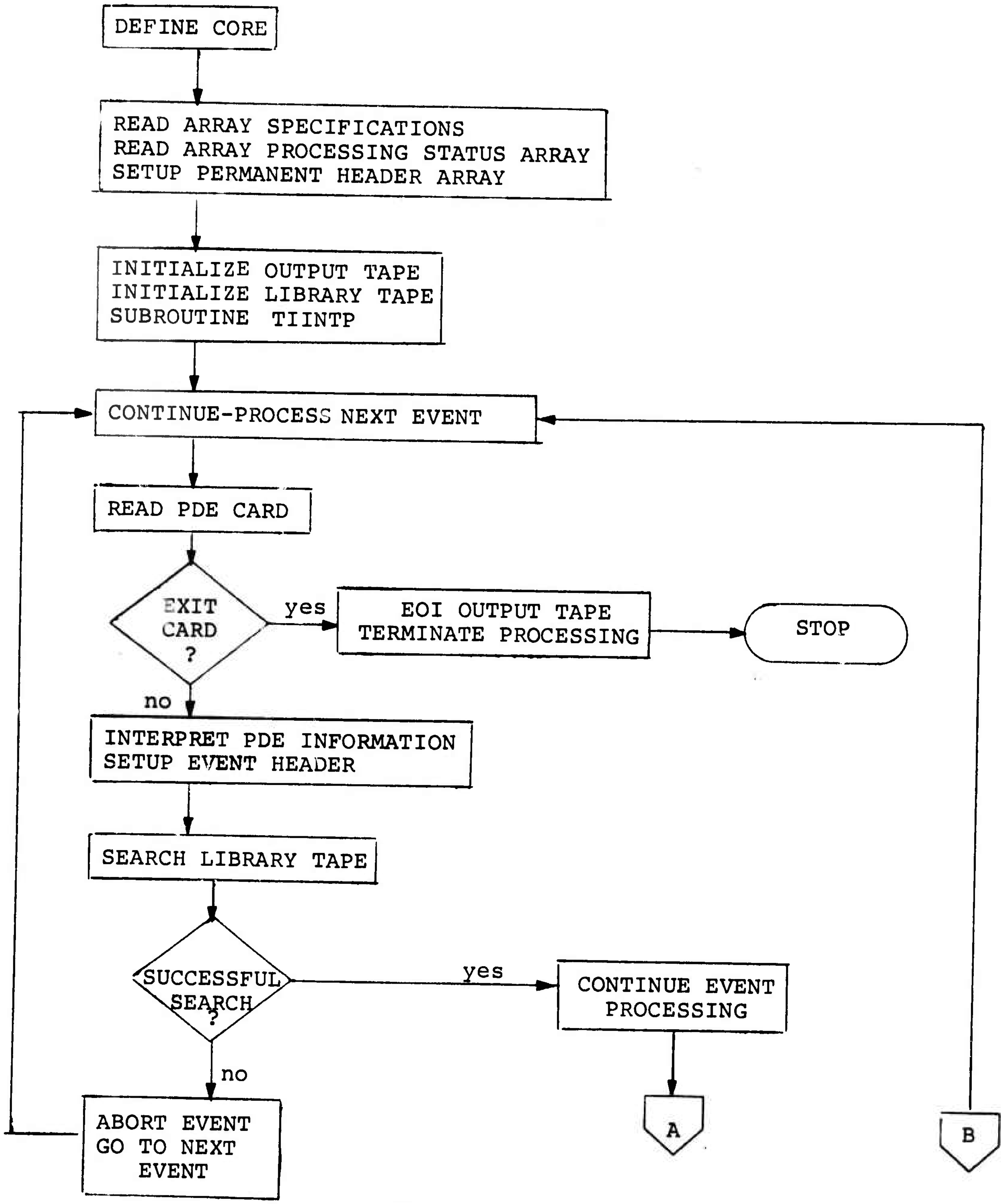


FIGURE V-2

GENERAL FLOW
LXEDIT

PAGE 1 OF 2 PAGES

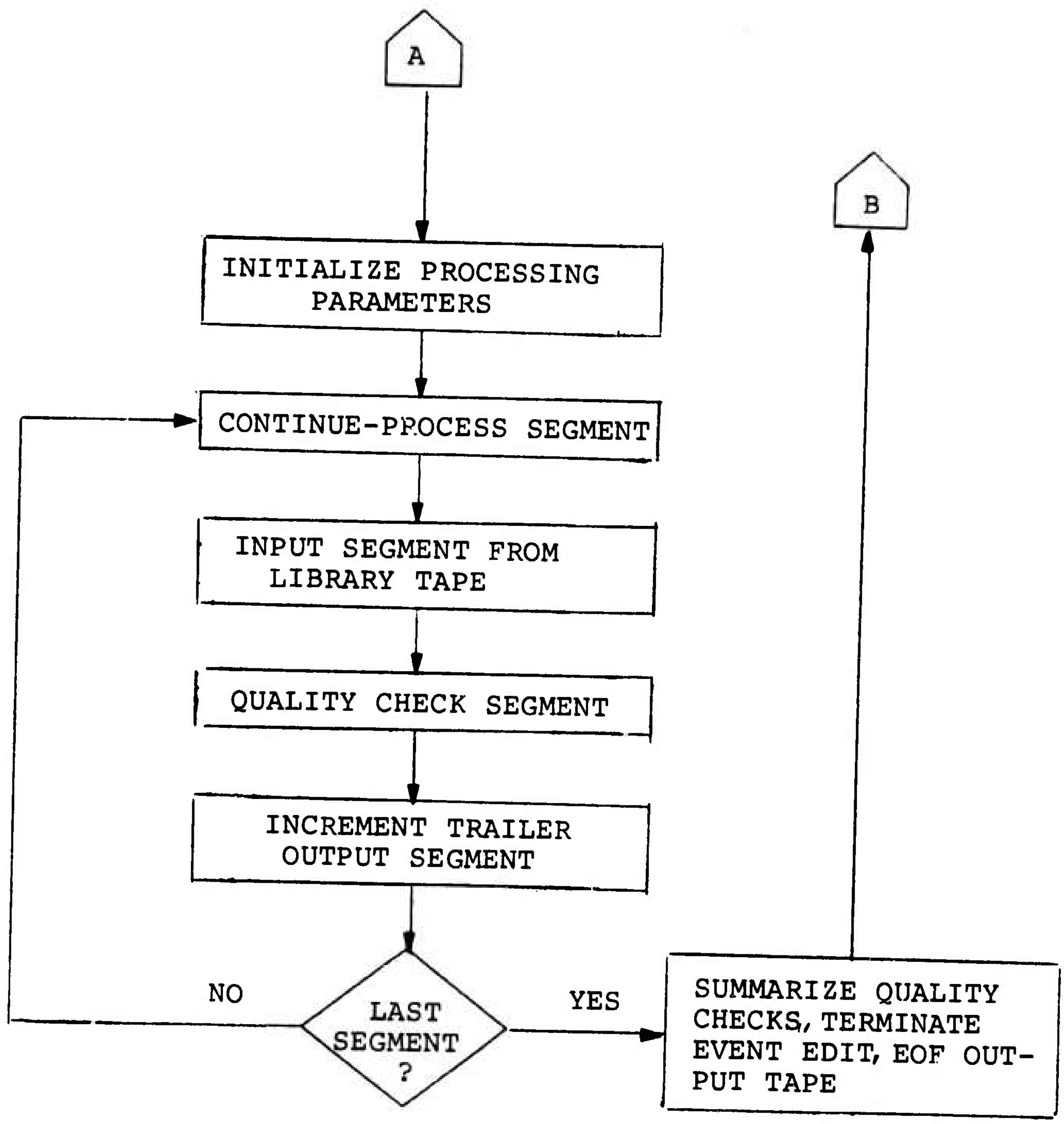


FIGURE V-2 (Cont'd)

GENERAL FLOW
LXEDIT

PAGE 2 OF 2 PAGES

flagged for later processing. Then, the data are written on a time domain data tape. After all segments are processed, a data summary is accumulated and printed. This output includes component means and powers, a list of bad segments for each station-component, and a quality check summary.

5. LXPLOT

The program LXPLOT gives the analyst a Calcomp plot of the data he has edited from the library tpae. He may choose all or any portion of the data to be plotted and he also has the option to plot raw traces (V, N, E) or rotated traces (V, T, R). This program is analogous to the ALPA off-line program EVPLOT.

6. LXGEN

LXGEN generates raw and/or processed data traces to be used in the trace analysis program. The general flow for the program is shown in Figure V-3. The program is composed of two main subsections, noise and signal processing. Either or both of the subsections may be performed on a specific event.

The first program function is the initialization of program processing parameters and tape positioning. Then the program checks to see if noise analysis is to be performed. In noise processing the following steps are performed on each noise segment:

° Read segment from tape

° Fourier transform 128 or 256 data points (for all components) and smooth

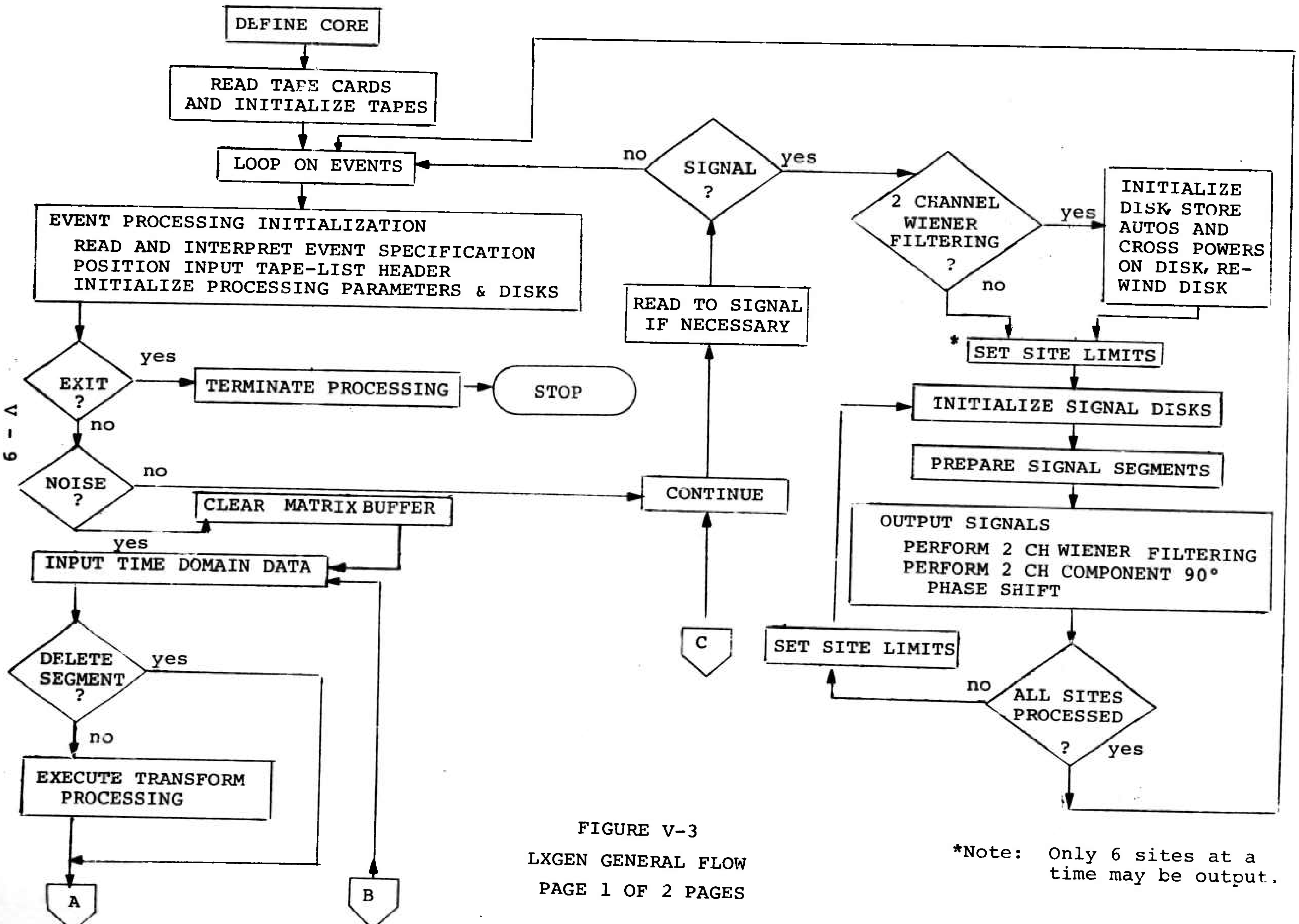


FIGURE V-3

LXGEN GENERAL FLOW

PAGE 1 OF 2 PAGES

*Note: Only 6 sites at a time may be output.

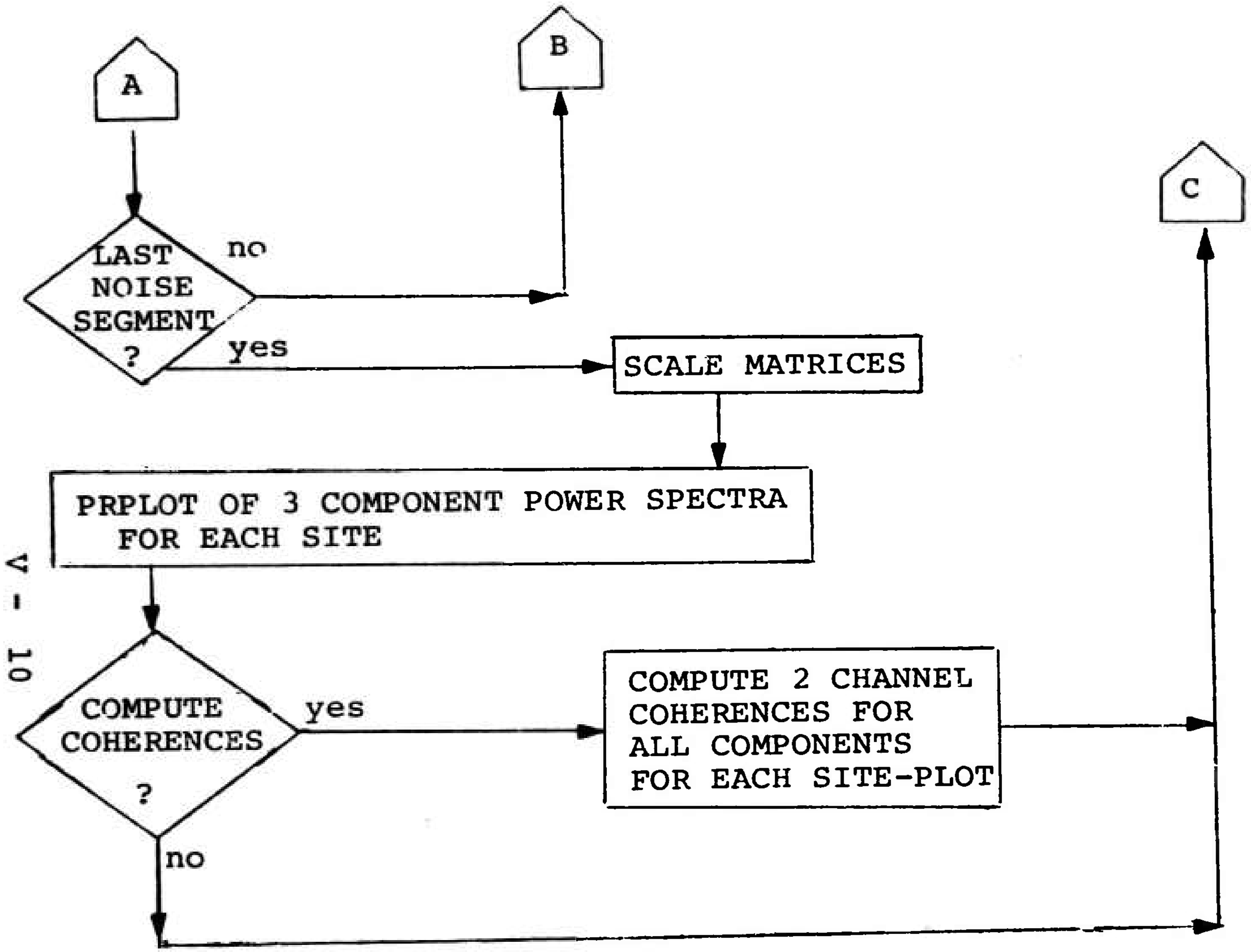


FIGURE V-3 (Cont'd)
LXGEN GENERAL FLOW
PAGE 1 OF 2 PAGES

7. LXTRAN

The raw data traces and/or processed traces from LXGEN are analyzed in this program. LXTRAN basic flow is shown in Figure V-4. The basic functions of the program are:

- ° Generate event processing parameters and position tapes
- ° Generate input and output processing arrays
- ° Input trace from tape and Fourier transform desired mode or modes
- ° Apply matched filters and/or band pass filters to transforms
- ° Compute and printer plot power spectra
- ° Inverse Fourier transform, plot time domain trace, and output trace to tape
- ° Compute discrimination statistics
- ° Compute and plot LQ and LR group velocity curves if specified
- ° Examine Rayleigh wave for presence of higher order modes using a high resolution, moving-gate spectral estimate. Note that this program may be a separate package if core storage requirements are excessive

8. LXMULT

The last processing package is the multi-station event processing. The functions of this program have not been

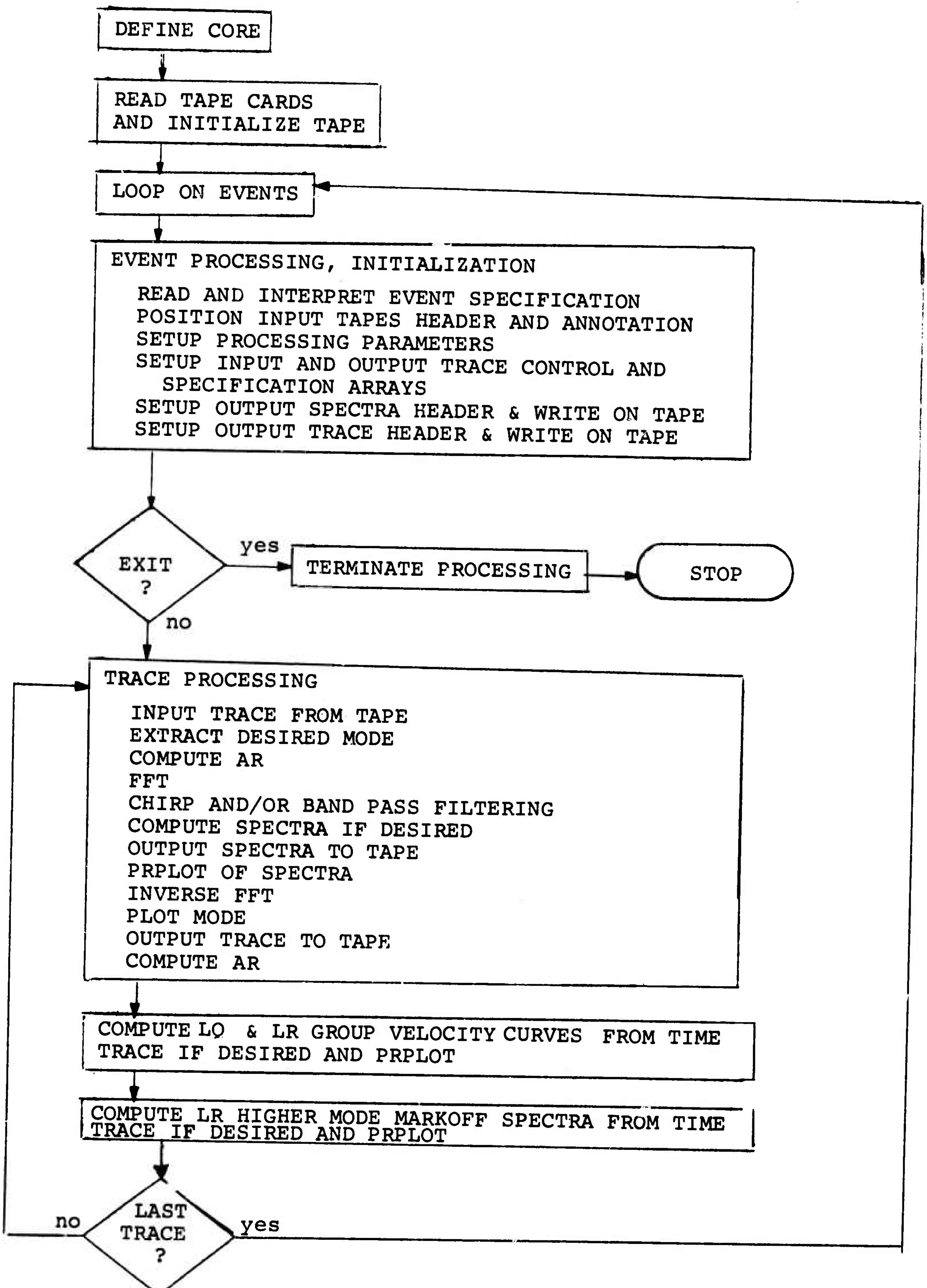


FIGURE V-4
GENERAL FLOW
LXTRAN

- Stack all noise segments

- Bandpass filter and rotate transforms to primary beam directions

- Generate a 3 by 3 crosspower spectral matrix for each station at all desired frequencies

- Printer plot the component power spectra for each station

- Calculate and printer plot two-channel coherences for each station

The program then checks to see if signal anaylsis is to be performed. The following signal processing functions are performed.

- If necessary, save previously computed crosspower spectral matrices for 2 channel Wiener filtering

- Generate and output to tape a raw data trace for each component for each site.

- Design a two-channel frequency domain Rayleigh-wave MCF for each site from the radial and vertical components, inverse Fourier transform the filters and printer plot their impulse responses. Apply the filters to their respective data traces, and output the resultant trace to tape. Also the output trace may be Calcomp plotted.

- Design and apply a ninety-degree phase shift operator to the radial components and sum with their respective vertical components over the Rayleigh wave gate. Output the resultant trace to tape and Calcomp plot if desired.

completely defined at the present time.

C. FUTURE PLANS

During the next quarter, all programs will be defined, tape formats will be specified, and coding and debugging will begin.

It should be pointed out that close cooperation among the organizations involved in the long Period Experiment will be necessary to ensure the success of the program. We suggest that a review meeting should be held in the near future, and that periodic reviews be conducted at about six-week intervals thereafter.

SECTION IV
REFERENCES

1. Texas Instruments Incorporated, 1969: Long Period Array Processing Development, Quarterly Report No. 1, Contract F33657-69-C-1063, 8 August.

2. Texas Instruments Incorporated, 1969: Long Period Array Processing Development, Quarterly Report No. 2, Contract F33657-69-C-1063, 10 November.

3. Texas Instruments Incorporated, 1970: Long Period Array Processing Development, Quarterly Report No. 3, Contract F33657-69-C-1063, 10 February.

APPENDIX A

ALPA ON-LINE OPERATING INSTRUCTIONS

On questions concerning the ALPA on-line program, notify Tom Barnard (office phone 244-3976, home phone 493-6427). If he cannot be reached, notify Terry Harley (office 244-4894, home phone 588-3447). If he cannot be reached, notify Steve Benno (office 244-3948, home phone 762-8254).

I. TO START ALPA ON-LINE PACKAGE (FROM 40X)

Make sure the ALPA link is up. There is an open gray-colored rack (the time-of-day hookup) behind and to the left of the 50 hertz SPS processor in the inner computer room. There is a white foam plastic cover over part of the top half of this rack. The ALPA link is up when there is no light on in the left hole cut in the foam plastic and a light is flashing once per second in the right hole cut in the foam plastic. If the ALPA link is not up, the ALPA on-line package cannot run. In this event, notify the ALPA on-line user.

Mount disk pack S-04 on '1A0' and a scratch pack on '1A1'.

Mount the two tapes specified by the ALPA on-line user on 9-track drives. The ring must be in on both tapes, and the tapes must be rewound.

The 2911 MPX switch must have the B buttons in the center column set to "OFF" prior to IPL. When the button is

ATTACHMENT 1

STARTUP PROCEDURE FOR
ALPA ON-LINE PACKAGE

(2911 MPX switch must be off for IPL)

```
   0I10A GIVE IPL CONTROL COMMANDS
set date=05/05/70,clock=21/06/00
BG 0I20I DOS IPL COMPLETE
BG 1I00A  READY FOR COMMUNICATIONS.
BG B  <----------------------------------(load ALPA deck prior to depressing EOB)
BG     ALLOC F1=44K
BG     ASSGN SYSLST,UA
BG     ASSGN SYSIN,UA
BG 1C10A  PLEASE ASSIGN SYSRDR. <--------------(do not assign SYSRDR)
BG stop
AR 1I60A  READY FOR COMMUNICATIONS.
AR batch f1
F1 assgn sysin,x'00c'
F1 B  <----------------------------------------------(give end of block)
F1     ASSGN SYSLST,X'1A1'
F1     ASSGN SYS015,X'03F'
F1     ASSGN SYS016,X'00C'
F1     ASSGN SYS017,X'00E'
F1     ASSGN SYS018,X'036'
F1     ASSGN SYS019,X'035'
F1 // PAUSE ASSIGN TAPE DRIVES TO SYS006 AND SYS007
F1 // assgn sys006,x'243'
F1 // assgn sys007,x'242'
F1 B  <----------------------------------------------(give end of block)
F1 // PAUSE FLIP 2911 MPX SWITCH TO B4 SETTING IF NOT ALREADY FLIPPED
F1
F1     ASSGN SYSIN,UA
F1 1C10A  PLEASE ASSIGN SYSRDR. <--------------(do not assign SYSRDR)
F1 // exec tiphase1
F1 NO INITIALIZATION INPUT ERRORS

F1 ALPA ON-LINE PACKAGE READY TO RECEIVE UPDATES

F1 SAAC DEVELOCORDER INTERRUPT RECEIVED

F1 BLOCK PROCESSOR NOT COMPLETE AT 125.21.08.20

F1 VSC DEVELOCORDER INTERRUPT RECEIVED

AR 1I60A  READY FOR COMMUNICATIONS.  }
AR start                              } <----(to start job stream)
BG assgn sysin,x'00c'                 }
BG assgn syslst,x'00e'                }
BG // job debe                        }
BG // JOB DEBE                        } <----(job stream)
   21.12.15                           }
```

Note: words inside parentheses are comments

the IPL. If it was properly executed, notify the ALPA on-line user.

The messages "TAPE ERROR. REWIND AND MADE READY SYS006." and/or "TAPE ERROR. REWIND AND MAKE READY SYS007." may appear. They are caused by the failure to read without errors a record with "VOL1" in the first four characters and to write without errors a header label on SYS006 or SYS007. Rewind and make ready the tape specified. Then give an end-of-block to continue. If the message persists, mount the next available tape in sequence. If the message occurs with the new tape, dismount the new tape, clean the tape drive, and mount the original tape. Then give an end-of-block to continue.

The messages "ALPA ON-LINE PACKAGE READY TO RECEIVE UPDATES" and "BLOCK PROCESSOR NOT COMPLETE AT xxx.xx.xx.xx" should now appear. If they do not appear, notify the ALPA on-line user.

After these two messages, the messages "VSC DEVELOCORDER INTERRUPT RECEIVED" and "SAAC DEVELOCORDER INTERRUPT RECEIVED" should appear. Either may appear first. If the message "VSC DEVELOCORDER INTERRUPT RECEIVED" does not appear, notify the ALPA on-line user. If the message "SAAC DEVELOCORDER INTERRUPT RECEIVED" does not appear, check the 2701 on-line/off-line switch marked with red crayon inside the 2701 Data Adapter behind the 40B console next to the Clevite Strip chart recorder and experimental console. Make sure that the switch is set to "ON-LINE." If the message "SAAC DEVELOCORDER INTERRUPT RECEIVED" does not appear within two or three minutes, notify the ALPA on-line user. If he cannot be reached, permit the ALPA on-line program to continue.

To start background partition processing, hit the request key on the console typewriter. This action generates the reply "AR 1I60A READY FOR COMMUNICATIONS." Type the messages shown on Attachment 1 through "BG assgn syslst, x '00e'." The computer is ready to run job stream in the background partition.

II. OPERATING INSTRUCTIONS WHILE ALPA ON-LINE PROGRAM IS RUNNING

A. ALPAPRT

Alternately every 55 minutes or 65 minutes, the message "F1 EXECUTE THE PROGRAM NAMED ALPAPRT" will be typed and the console bell will ring. This program must be executed in order to dump the on-line printout onto the printer. If the program running does not finish within 45 minutes after the message to run ALPAPRT, it must be cancelled by hitting the request key and typing the reply "cancel bg" (without a dump).

The program ALPAPRT is a job which may be run in either foreground 2 or background. A deck has been supplied to run it. This deck is shown on Attachment 2. It dumps the printout from disk '1A1' to the printer, and should run in less than five minutes. The printout should be collected from successive runs and placed in a binder. The ALPA user will pick up the binder when it is full. Attachment 3 shows the messages necessary to run ALPAPRT in background. In order to run additional background job, SYSLST must be reassigned (permanently) to the printer as shown in Attachment 3. Attachment 4 shows the messages necessary to run ALPAPRT in foreground 2.

Once ALPAPRT is run, ordinary job stream may run in the background partition again.

ATTACHMENT 2

JCL FOR PROGRAM ALPAPRT

```
//  JOB ALPAPRT
//  VOL SYS001,IJSYSLS
//  DLAB 'SYSTEM LIST FILE                                        1111111',      C
               0001,70001,70001,'DOS          ',SD  (column 54) (column 72)
//  XTENT 1,0,000188000,000198009,'111111',SYS001
//  ASSGN SYS001,X'1A1'
//  ASSGN SYS002,X'00E'
//  EXEC ALPAPRT
//  ASSGN SYS002,UA
/&
```

Note: Phrases in parentheses are comments, all other phrases are from control cards

ATTACHMENT 3

PROCEDURE FOR RUNNING ALPAPRT

IN BACKGROUND

```
BG  stop
F1  EXECUTE THE PROGRAM NAMED ALPAPRT
AR  1I60A  READY FOR COMMUNICATIONS
AR  batch bg
BG
BG  //  JOB ALPAPRT
    01.54.25
BG  0P08A      INTERV REQ SYSLST=00E
BG  0P08A      INTERV REQ SYS002=00E
BG  0P08A      INTERV REQ SYS002=00E
BG  EOJ ALPAPRT
    01.57.09,DURATION 00.02.43
BG  1C00A  ATTN. 0 0C
BG  assgn syslst,x'00E'                       } 
BG  stop                                      } (to avoid tying up type-
BG  0P08A      INTERV REQ SYSLST=00E          }  writer)
AR  1I60A  READY FOR COMMUNICATIONS.          }
AR  batch bg                                  }
BG
BG  //  JOB HEITING                           }
    02.00.16                                  }
BG  *  CONTROL NO. 5905 *****                 } (job stream)
BG  *  CLASS                                  }
BG  *  ASSIGN L-1413 TO SYS005 (RING OUT)     }
BG  //  PAUSE                                 }
```

Note: phrases in parentheses are comments, all other phrases are typewriter I/O

ATTACHMENT 4

PROCEDURE FOR RUNNING ALPAPRT

IN FOREGROUND 2

```
BG   assgn sysin,ua
BG   assgn syslst,ua
F1   EXECUTE THE PROGRAM NAMED ALPAPRT
AR   1I60A  READY FOR COMMUNICATIONS.
AR   batch f2
F2   assgn sysrdr,x'00c'
F2
F2   //  JOB ALPAPRT
     23.15.32
F2   EOJ ALPAPRT
     23.17.37,DURATION 00.02.05
F2   1C00A  ATTN. 0 0C.
F2   assgn sysin,ua
F2   stop
BG   0S12I  SUB SSWINP CANCELLED DUE TO MAINTASK TERMINATION  (background
BG   1I00A  READY FOR COMMUNICATIONS                             job
BG   stop                                                     terminated)
AR   1I60A  READY FOR COMMUNICATIONS
AR   start bg
BG   assgn syslst,x'00e'
BG   //  assgn sys000,'186'
BG   //  exec debe                              (job stream)
```

Note: phrases in parentheses are comments, all other phrases are typewriter I/O

B. TYING UP TYPEWRITER

Care should be exercised so that the typewriter is not tied up waiting to read messages from the operator. An example of such a situation is the message "BG" which appears when no jobs are in the card reader after a background job is complete. If no background job can be run, reply "stop bg" instead of B. When a job is again available, hit the request key and type "batch bg" in reply to the standard message "AR 1I60A READY FOR COMMUNICATION."

C. 2911 SWITCHES

Do not flip 2911 MPX or 2911 SELECTOR switches connected to 40X while the ALPA on-line program is running.

D. OTHER MESSAGES REQUIRING OPERATOR ACTION

For the following messages:

"ALPA TAPE CHANGE AT xxx.xx.xx.xx"
or
"ALPA TAPE EQUIPMENT CHECK AT xxx.xx.xx.xx"
or
"EXCESSIVE ALPA TAPE PARITY ERRORS AT xxx.xx.xx.xx"
or
"ALPA TAPE DEVICE END NOT POSTED AT xxx.xx.xx.xx"
or
"UNDIAGNOSED ALPA TAPE ERROR AT xxx.xx.xx.xx"

Mount the next sequential tape on the drive whe[illegible] tape rewinds. If, for example, T00003 rewinds and T00004 is on the remaining drive, mount the next tape in sequence

(T00005) on the drive where T00003 was located.

For "MAKE ALTERNATE ALPA TAPE READY. NOTIFIED AT xxx.xx.xx.xx". Make the tape drive ready on the unit not being written on. This action may require mounting a new tape (the next in sequence as described previously.)

For "REFER TO ALPA OPERATING MANUAL. ALPA LINK DOWN AT xxx.xx.xx.xx". Notify the user. If the user cannot be reached, put computer in hard stop and depress OFF button on 2911 MPX switch in the center column (B buttons). Take card - loaded dump. Discontinue running the ALPA on-line program.

For "UNABLE TO WRITE ALPA TAPE RECORD. UNIT STILL BUSY AT xxx.xx.xx.xx". Cancel the background job and rerun job on different machine if this message persists.

For "OP77I JOB XXXXXXXX CANCELLED DUE TO INVALID ADDRESS". A background job may have exceeded the background storage allocation of 180K bytes. Rerun the job on another machine.

For "BLOCK PROCESSOR NOT COMPLETE AT xxx.xx.xx.xx". If this message persists, channel 1 probably has been tied up. Ordinarily this condition is caused by tape or disk I/O from the background partition monopolizing channel 1. If it is likely that the background job will continue to tie up channel 1 for more than ten minutes, cancel the background job and rerun it on a different machine.

It is possible, however, that error conditions on the disk packs have prevented the supervisor from accessing

transient routines on 1A0. If conditions requiring intervention on some device do not generate the typed message "INTERV REQ SYSxxx=nnn", this is probably the case. It will be impossible to run additional background jobs if this condition has occurred. In this event, follow the procedure described in subsection E (IF SYSTEM BLOWS UP). Be sure to take a card-loaded dump.

For "NO TRANSMISSION READ ON ALPA LINK FOR TEN MINUTES"

or

"NO TRANSMISSIONS READ ON ALPA LINK FOR 9 MIN 52 SEC". If the ALPA link is not transmitting, notify the user any time, day or night. At some time in the future, the procedure will be to contact the ALPA Maintenance and Monitoring Center, but arrangements have not been worked out yet.

If the ALPA link is transmitting, first check to see whether the tape is writing once every fifteen seconds. If is is, permit the program to continue unless the message recurs and the ALPA link is still transmitting. If the tape is not writing every fifteen seconds, notify the user.

For "INTERRUPTS FROM VSC DEVELOCORDER CEASED. I/O RESTARTED"

or

"UNCORRECTABLE ERROR ON VELA LINK. I/O RESTARTED." If either of these messages persists, attempt to locate an engineer within the SAAC facility. Tell him that the VELA 2701 is malfunctioning and ask him to correct the problem. If no engineer can be found within the SAAC facility, notify the user.

E. IF SYSTEM BLOWS UP

Put computer in hard stop and depress "OFF" button on 2911 MPX switch in the center column (B buttons). Take a card-

loaded dump. Put at least four (4) tape marks at end of tape being written on. Notify the user any time, day or night.

If a machine check occurs for which the cause is known (i.e., someone flipped 2911 switch or an engineer disconnected a 2701, etc.), there is no need to take a card-loaded dump. If the cause of a machine check is unknown, depress LOG OUT button on central processor and take a SEREP dump to aid service engineers in fixing machine.

F. IF TAPE DOES NOT WRITE EVERY FIFTEEN SECONDS

If the ALPA link is up wait 10 minutes. Then notify the user any time, day or night.

If the ALPA link is not transmitting, wait 10 minutes. (It takes the computer in Alaska roughly 2-3 minutes to come back up in the event of an error). If link is not up within ten minutes, notify the user any time, day or night.

G. TYPEOUT

Save typeout from ALPA on-line program. Label it "ALPA ON-LINE TYPEOUT." Return to user.

H. TAPE LABELING

The following information should be written on the tape labels:

Reel number - number of reel on which data was written.

Assignee - TEX INS

Creation date - Date tape was started (GMT)

Data date - Date tape was started (GMT)

Start Time - Time of first data on tape. This time can be obtained from the first ALPAPRT listing after program startup. The first line of printout contains "TIMING CODE ddd.hh.mm.ss ILLEGAL GAIN CODES xxx etc." The value "hh.mm.ss" is the start time. After a tape change, it may be obtained from the typewriter in the message "ALPA TAPE CHANGE AT ddd. hh.mm.ss."

Stop time - If the program goes down, estimate the time as accurately as possible. After a tape change, it may be obtained from the typewriter message "ALPA tape change at ddd.hh.mm. ss."

BPI - 1600

TR - 9

Tape dr. - Number of tape drive on which tape was written.

Tape - ATS/IH

RC - A

Disk - Number of disk used as system disk

Comments - ALPA LIBRARY TAPE START xxx STOP yyy. "xxx" is the Julian date on which the tape is begun, "yyy" is the Julian date on which the tape ends.

Run no. - 9978

An example of a completed tape label is shown in Attachment 5.

ATTACHMENT 5

TAPE LABEL EXAMPLE

REEL NO.	ASSIGNEE	CR DATE
T00099	TEX INS	12 / 31 / 70

DATA DATE	START TIME	STOP TIME
12/31/70	09:30:00.	08:30:00.

BPI	TR	TAPE DR.	TYPE	RC	DISK	ERR
1600	9	243	ATS / IH	A	4	

COMMENTS	ALPA LIBRARY TAPE START
365 STOP 001	

1 2 3 4 RUN NO. 9978

III. TO TERMINATE RUN

Hit the request key on the 1052 console typewriter. This action generates the standard reply "AR 1I60A READY FOR COMMUNICATIONS." Reply "msg f1." Another line will appear with the prefix "AR". Type "STOP" using capital letters and indicate end-of-block. After a few seconds, the message "F1 UPDATE COMPLETE AT xxx.xx.xx.xx" should appear and the ALPA library tape should rewind. Wait a few seconds to allow any remaining typeout to appear.

IV. TO RESTART SYSTEM

The tape being written on in the prior run should have had four tape marks written at the end of it. This tape is the "prior tape" for the new run. The last card in the ALPA data deck should have the volume number for this tape in columns 75-80 and the card identifer "VOLUME NUMBER FROM PRIOR TAPE" in columns 1-29. For example, if T00007 was being written on in the previous run and T00008 was the alternate unit, "T00007" should be substituted in columns 75-80. T00008 should be assigned to SYS006, and T00009 should be assigned to SYS007 for the new run.

After the last card in the ALPA data deck has been changed (as described above) and the tapes have been cycled for the new run, follow the procedure described in Section I.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) TEXAS INSTRUMENTS INC. Services Group P.O. Box 5621, Dallas, Texas 75222	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

LONG PERIOD ARRAY PROCESSING DEVELOPMENT
QUARTERLY REPORT NO. 4

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

QUARTERLY REPORT NO. 4, 1 February, 1970 through 30 April, 1970

5. AUTHOR(S) (First name, middle initial, last name)

Harley, Terence W.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
10 May, 1970	134	3

8a. CONTRACT OR GRANT NO. Contract No. F33657-69-C-1063 b. PROJECT NO. AFTAC Project No. VT/9707 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) — 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) —

10. DISTRIBUTION STATEMENT

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, AFTAC.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
ARPA Order No. 624	Air Force Technical Applications Center - VELA Seismological Center Headquarters, USAF, Washington, D.C.

13. ABSTRACT

This quarterly report is a summary of progress under Long Period Array Processing Development, Contract No. F33657-69-C-1063, during the period 1 February, 1970 to 30 April, 1970.